APR 2 1931

Heating · Piping and Air Conditioning

APRIL, 1931

Heating—
By THE STAFF OF
CLYDE R. PLACE

Piping—
By J. H. WALKER *and*
J. V. EDESKUTY

Air Conditioning—
By S. M. ANDERSON *and*
MORTIMER FREUND

Journal Section
of A. S. H. V. E.

...ion, Probst & White, Chicago—Ventilating Contractor, Riggs, Distler Co., Inc. Baltimore—Toncan Distributor; Fable & Co., Inc., Philadelphia.

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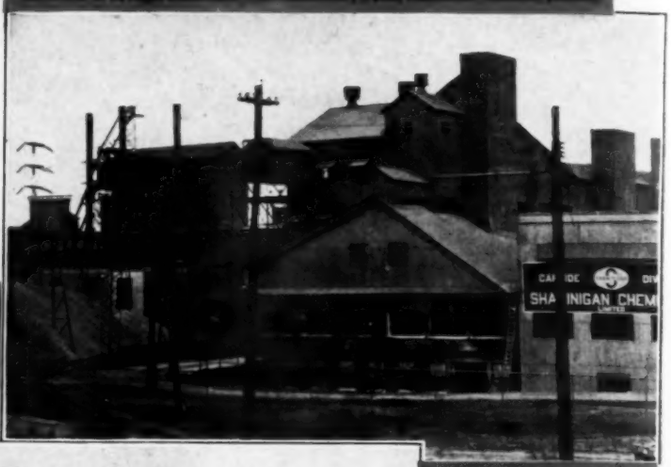

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The EDITOR'S PAGE

Heating · Piping and Air Conditioning

FROM ARTICLES IN THIS ISSUE

"Should the water level in the atmospheric tank drop sufficiently from any cause so as to open a balanced float valve, city water will enter the tank, providing water for the boiler feed pump, and if the pump fails will be fed directly by the automatic feeders."—*Samuel R. Lewis.*

"Steam at 1,000 F is hot steam. It scorches canvas insulation jackets and the clothing of anyone who comes near an unnoticed leak. The jet of steam issuing from a leak is invisible in air . . . and must be detected by means of rags on the end of a stick which are set afire by the escaping steam . . . The handling of steam at 1,000 F introduces several new and interesting problems in the design of the piping, super-heater, and turbine."—*J. H. Walker.*

"The ideal system for the air conditioning of a home is fundamentally one that will keep every occupied room in the house comfortably warmed and properly humidified during the winter, and refreshingly cooled and properly dehumidified in the summer."—*S. M. Anderson.*

"The new Waldorf-Astoria is unique, in so far as the mechanical equipment goes, in that no boiler plant will be installed in the building, which is practically without a basement. The area covered is almost all above usable train space, with a very limited horizontal pipe space over the whole lot between the track clearance line and the level of the floors above."—*Staff of Clyde R. Place.*

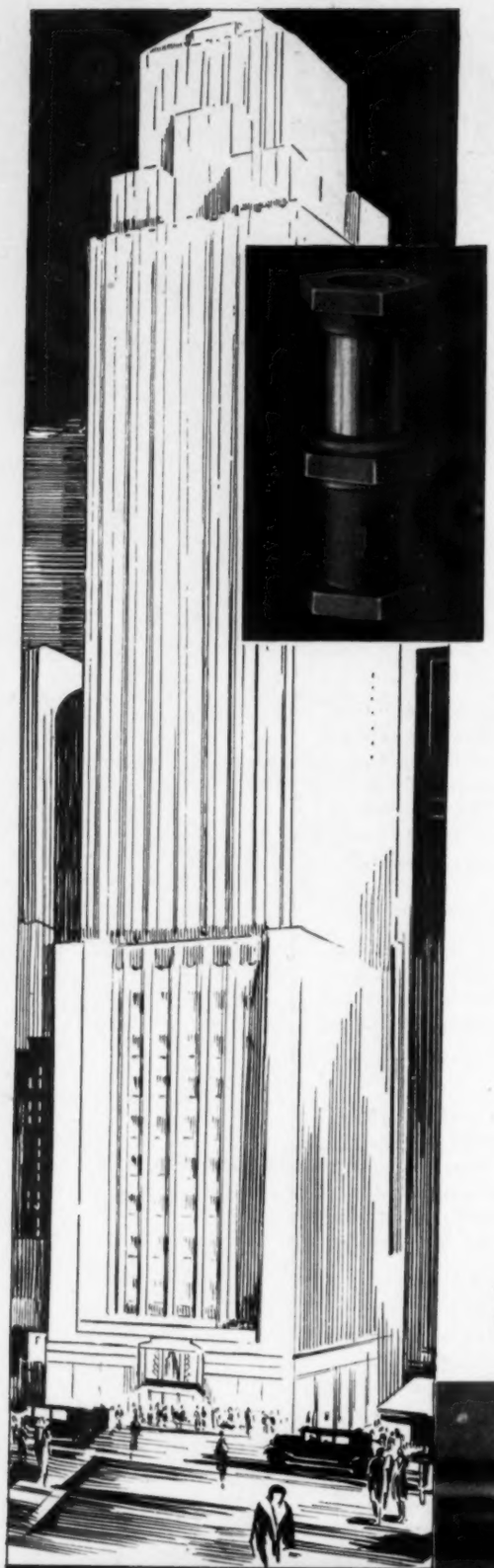
"The success of the accumulator is largely due to the regulating equipment which consists in the Waldorf Paper Products Co.'s installation of four sensitive valves. The value of the accumulator was estimated as follows . . . "—*J. V. Edeskuty.*

" . . . improper design of heating and air conditioning systems and inadequate provision for their accommodation in the building structure entail not only additional installation charges but also additional operating costs and the latter repeat year after year during the life of the building."—*Mortimer Freund.*

"The trend and practice today is to design and make all connections to the sterilizing apparatus so that no contamination of the water supplies is possible under any and all extreme conditions."—*Rollo E. Gilmore.*

"I read your magazine every month and always find several articles which I consider intensely interesting; I feel it is a very worthwhile publication."

"I have read the article in HEATING, PIPING AND AIR CONDITIONING with great interest. You have described the mechanical equipment in much detail, and the description is as nearly perfect as in any article I have ever read."



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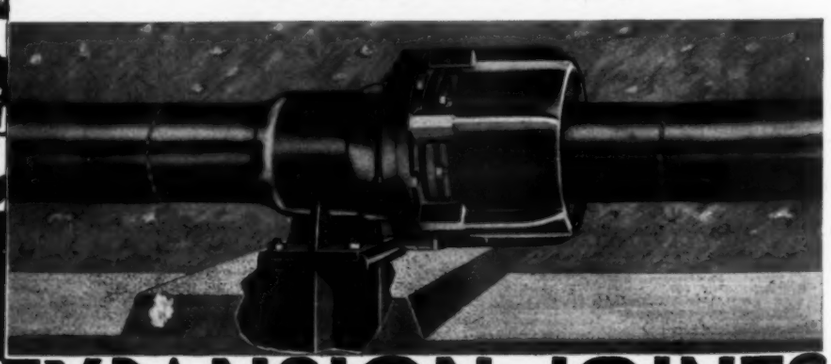

ADSCO EXPANSION JOINTS

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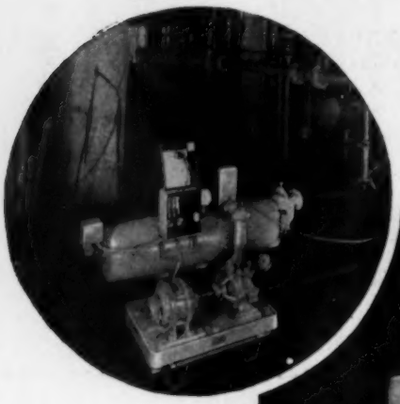
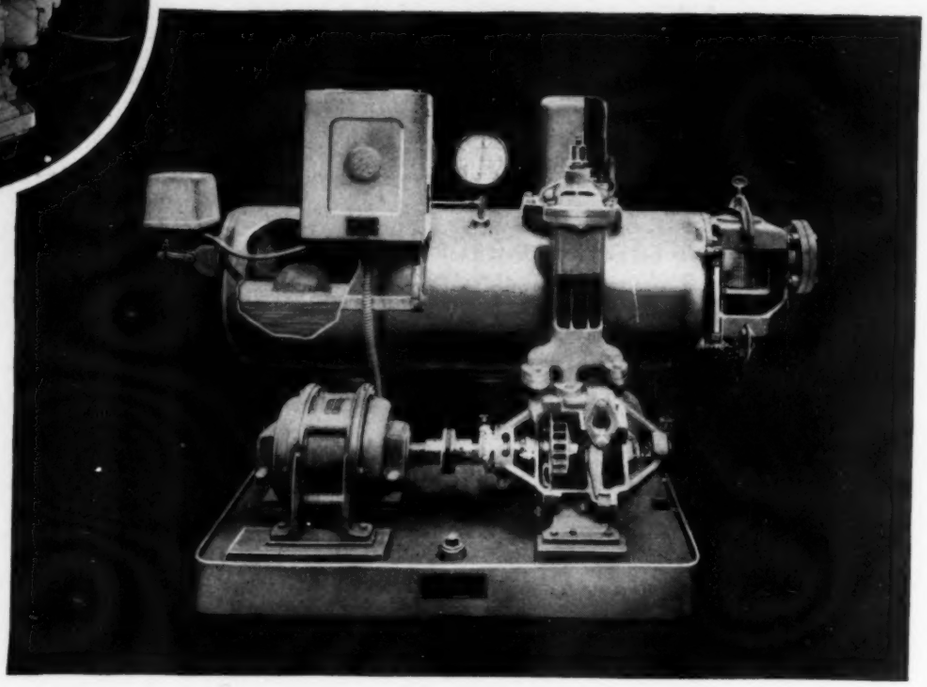


Jennings Pump on test in Nash laboratory.



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Heating · Piping and Air Conditioning

Vol. III | April, 1931 | No. 4

The New Hotel Waldorf-Astoria —A Description of the Heating and Piping Systems

By the Staff of Clyde R. Place*

(*Edited by Ernest Williams*)

THE NEW Hotel Waldorf-Astoria[1] is being erected on the site formerly occupied by the old New York Central Y. M. C. A. building, the New York Central power house, and the American Express building. This site occupies an entire block—Park avenue to Lexington avenue, and 49th to 50th streets. The size of the plot is 200 feet 10 inches on Park and Lexington avenues, and 405 feet on 49th and 50th streets.

Size of the New Building

The estimated value of the hotel when completed, including land, building and furnishings, is $40,000,000. The new hotel will be 46 stories, with an approximate height of 600 feet. The cubical contents of the building will be in excess of 20,000,000 cubic feet.

There will be 2,253 guest rooms, of which 300 will be parlors. Incidentally, all the rooms are exceptionally large.

There will also be de luxe suites and tower apartments. The tower will contain over 500 de luxe rooms with high ceilings, open fire places and boudoir baths, and generally follow the standards of the finest Avenue homes.

An unusual feature will be a private driveway and entrance to the hotel for the use of guests, 90 feet wide and 200 feet long, running through the center of the building from 50th to 49th streets.

THE NEW WALDORF-ASTORIA

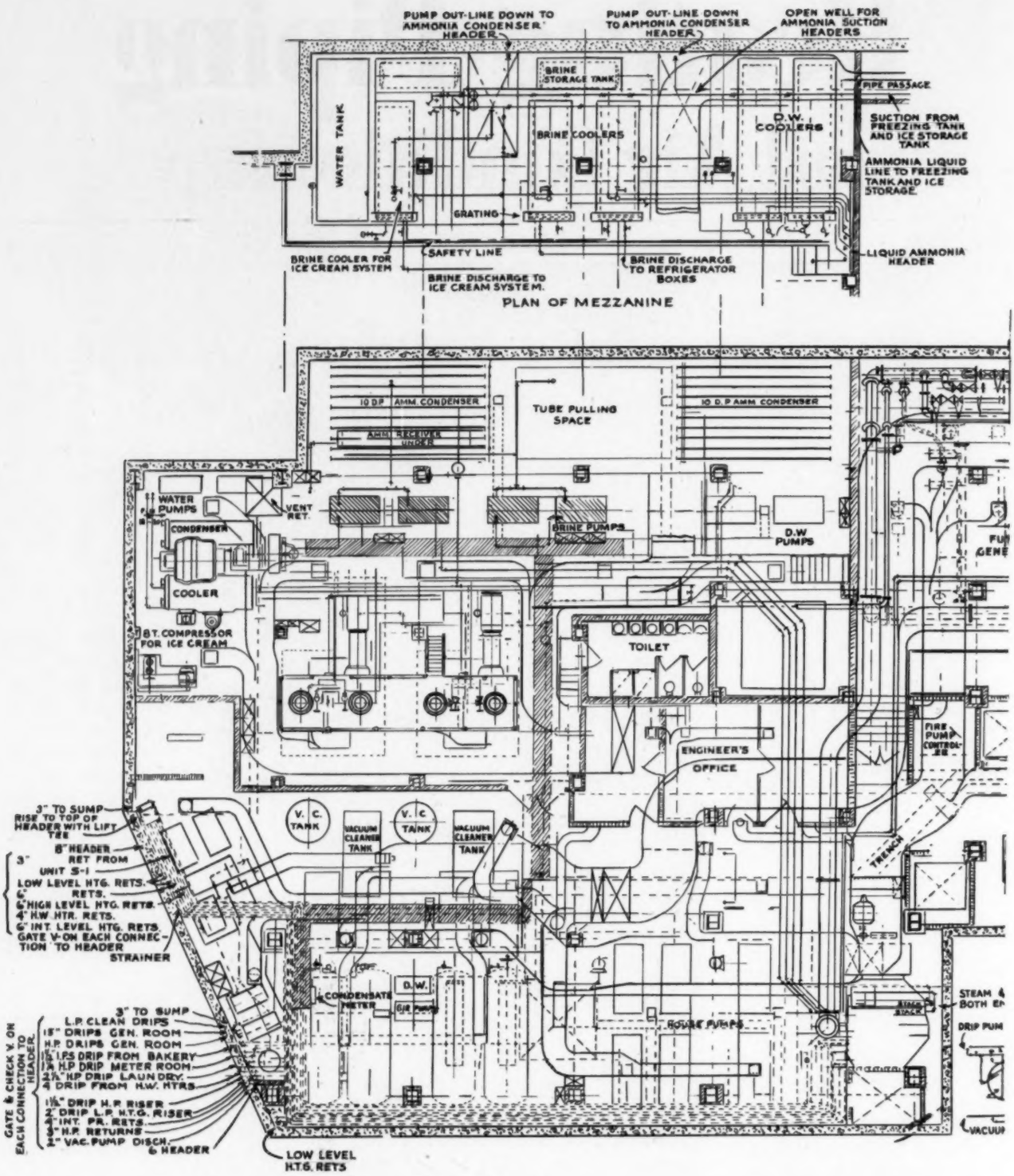
Ballrooms, Lobby, Exhibition Spaces

The main ballroom will be four stories in height, surrounded by three balconies. A large stage 60 feet wide, complete with the latest in stage equipment, dressing rooms, green room and the like will be at one end. There are three additional ballrooms, each with its separate foyer, in addition to the grand ballroom.

An exhibition space has been provided to take care of the growing demand for displays. A huge elevator will take automobiles, motor boats and other exhibits from the ground floor directly to it. By utilizing the ballrooms, which open into one another, a total exhibition space of 38,000 square feet can be made available.

[1] *Location*—Park Ave., 49th and 50th Sts. and Lexington Ave., New York City.
Owner—Hotel Waldorf-Astoria Corporation.
President—Lucius M. Boomer.
Architects—Schultze and Weaver.
Engineer—Clyde R. Place.
Builders—Thompson-Starrett Company, Inc.

*Consulting Engineer, New York City.



The lobby of the Waldorf-Astoria will be distinctly different in that it has been designed not to resemble a huge waiting room; while it is of a large area it has been designed to be called "friendly," and the *Peacock Alley* of the old Waldorf has not only been preserved but has been trebled in dimension.

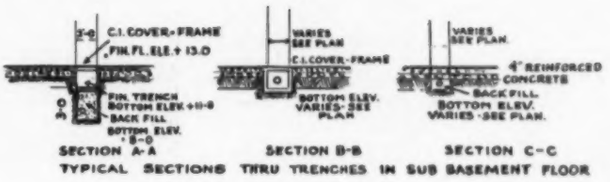
The *Rose Room, Empire Room,* and *Men's Cafe* so well and favorably known in the old Waldorf, are again featured in the new hotel. In addition, there will be a *Savarin Restaurant.*

The Roof Garden

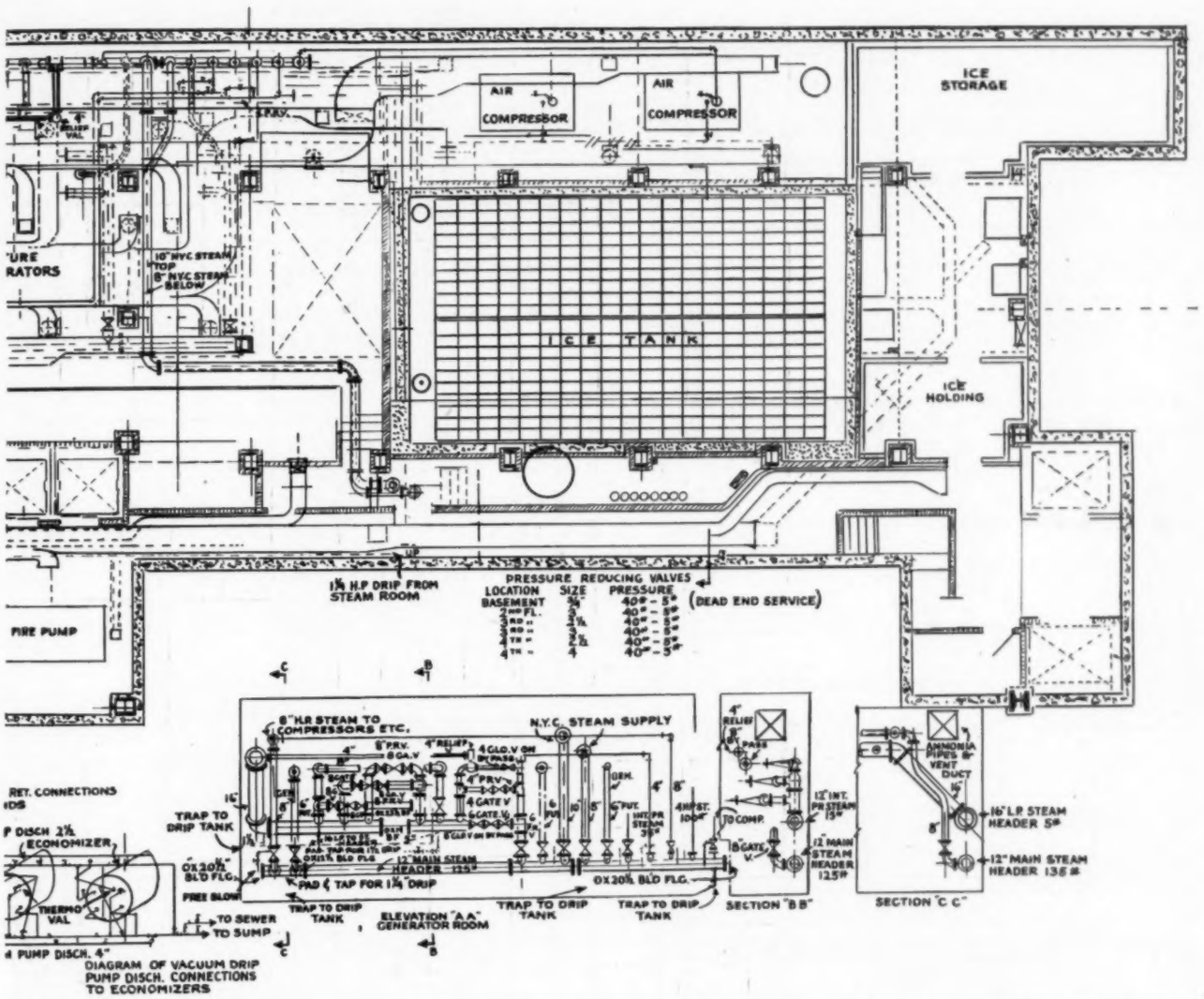
The entire Park Avenue front on the 18th, 19th and 20th floors comprise the *Roof Garden;* it will have outside terraces for dining.

The *Roof Garden* will have its own separate kitchen, which will also be located on the 18th floor. Room service kitchens will be located on the 18th floor as well, so that elevators will serve rooms from the 18th floor *down* to the 4th floor and from the 18th floor *up* to the 46th floor.

One of the unique features of the new Waldorf will be a private railroad siding underneath the hotel. Guests who own private railroad cars, can come directly to the Waldorf-Astoria and disembark alongside a special elevator, which will take them directly to the lobby, *Peacock Alley* or to their suites.



A Plan of the Sub-Basement of the Hotel Waldorf-Astoria



The hotel will be ready for occupancy about the middle of September, 1931.

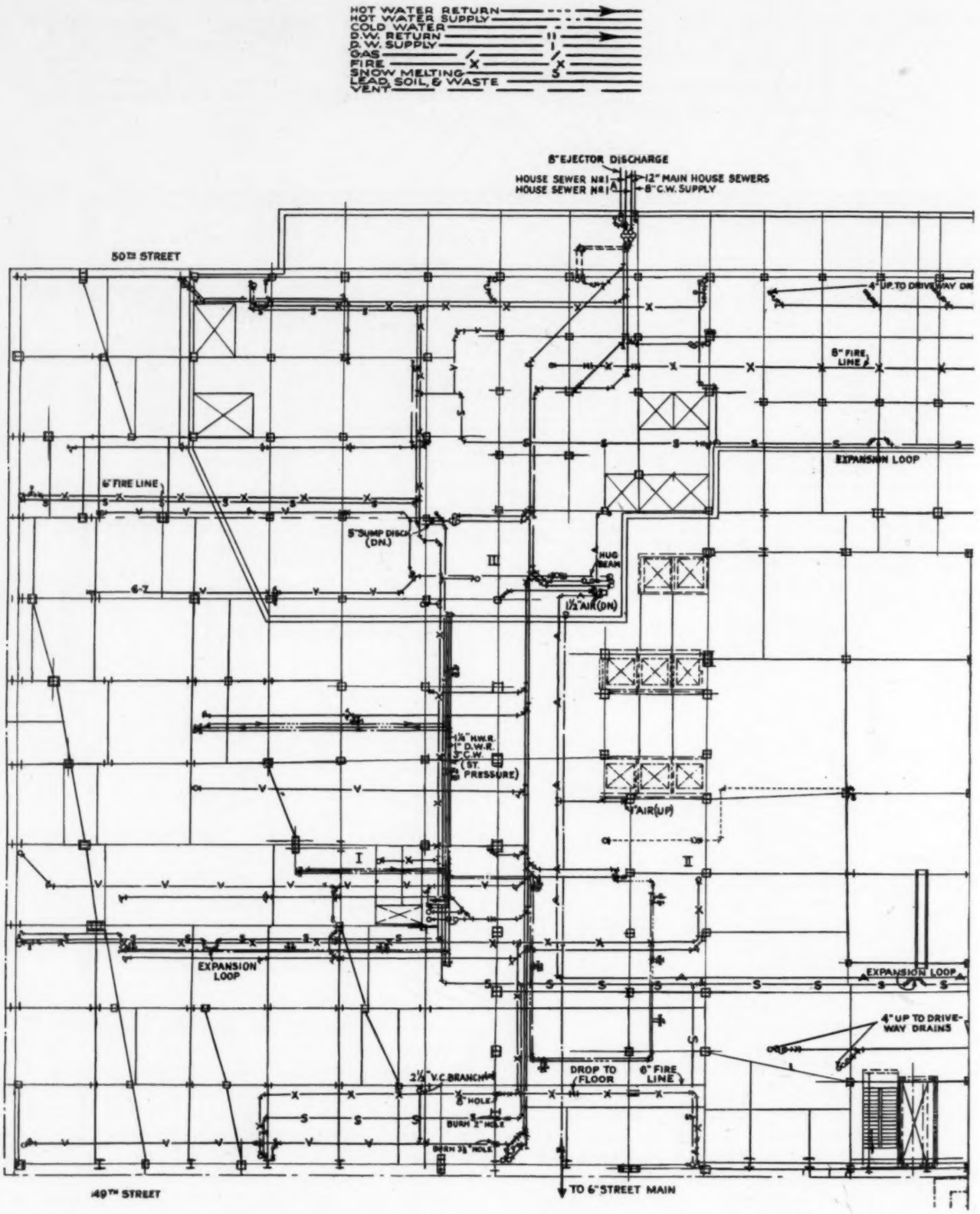
The Mechanical Systems

Mentioning the equipment and layouts which are our standard and customary practice has been avoided in this article. Only unusual features or features which we believe would be of special interest to the reader have been covered.

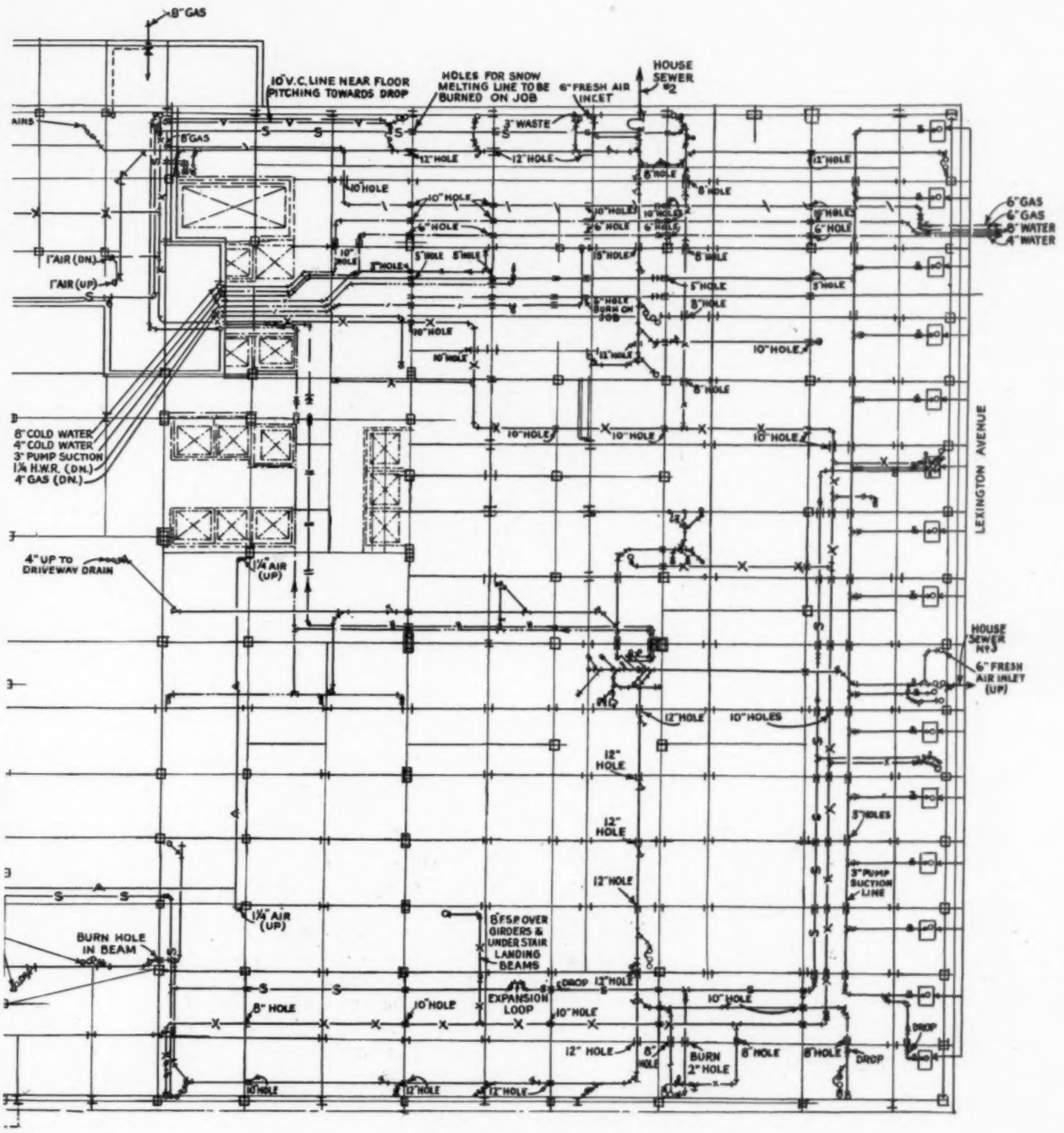
Because of the very small sub-basement, the equipment had to be fitted in the machine room very carefully, giving due consideration to accessibility and to the possibility of removing any equipment which might be damaged.

The importance of uninterrupted service in a hotel of this character required that standby provisions or standby interconnections be made wherever possible. This ultimate objective complicates the piping considerably, requiring by-pass lines and valves that would not be justifiable in a system where an interruption in service is not so vitally important. Every kind of material or equipment was selected with the object in mind of

A Plan of the Girder Space in the Hotel Waldorf-Astoria. It Was Necessary to Design the Piping Systems Before the Structural Steel Shop Drawings Could Be Approved, as the Holes in the Beams Had to Be Located



"The major portion of the building above grade is supported on girders above the New York Central tracks, and it is in this girder space below the ground floor that the steam and return mains run. There are over a hundred girders in this section of the structure alone, and the holes where the heating and plumbing lines pierced the steel were located, and the piping designed, before any of the other mechanical work of the building was designed."



getting good uninterrupted service, with minimum maintenance.

Steam and Electricity Obtained from Outside

The new Waldorf-Astoria is unique, in so far as the mechanical equipment goes, in that no boiler plant will be installed in the building, which is practically without a basement.

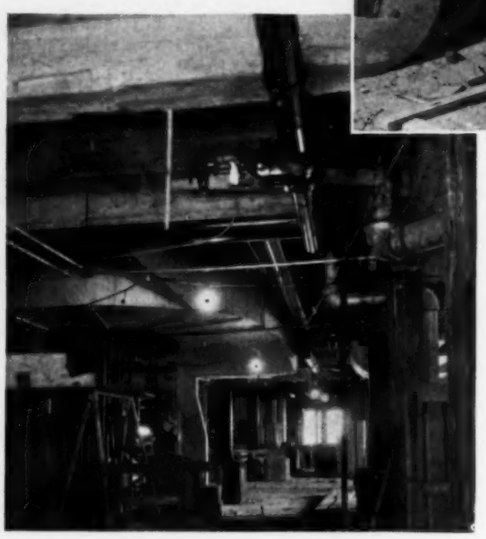
The area covered is almost all above usable train space, with a very limited horizontal pipe space over the whole lot between the train clearance line and the level of the floors above. All services for steam and electricity are therefore obtained from sources outside the building.

The steam is obtained from the mains with which the New York Central railroad distributes steam around through its terminal property and is brought into the building under an approximate average pressure of 125 pounds gage.

The electrical energy is direct current, obtained from the New York Central railroad's distributing system and is 120/240 for light and power.

There is no stack up through the building and no provision has been made for any future boiler plant. However, space has been provided for a future generator so that it may be installed if the heat balance and operating curves indicate the economy of this installation.

The heart of the mechanical equipment, which is located in the lowest basement, is confined to a very limited space and contains the house pumps, hot water heaters, refrigerating compressor, coolers, air compressors, ice making tank, preparation rooms, and the like.



Above—Steam Service Lines at Basement Level. These Lines Originate at Separate Sources and Enter the Building from Above the Track Space. Note Straps for Additional Strength

Left—View of the 17th Floor Ceiling. Steam Mains and Drainage Lines May Be Easily Seen, as Well as Ice-Water Circulating Lines. The Exhaust Duct Is the Intermediate Level Collecting System for Toilets

The Girder Pipe Space

The space between the ceiling clearance of the railroad and the floors above contains a great amount of structural steel and in many cases the steel is a solid vertical barrier from ceiling to floor through the entire area.

In it there is located the steam and return lines for the lowest section of the building, together with the medium pressure steam to certain kitchens and their returns. This space also contains the collecting lines for the sewage and leaders of the building, together with numerous runs of water piping.

A great many of the steel girders had to be penetrated for the piping to pass through, and reinforced to preserve their structural strength.

This work had to be done in the structural steel shops before the girders were delivered to the building; this necessitated a complete design of the piping in this area and its adaptation to the limitations imposed by the steel before any of the steel shop drawings could be finally approved.

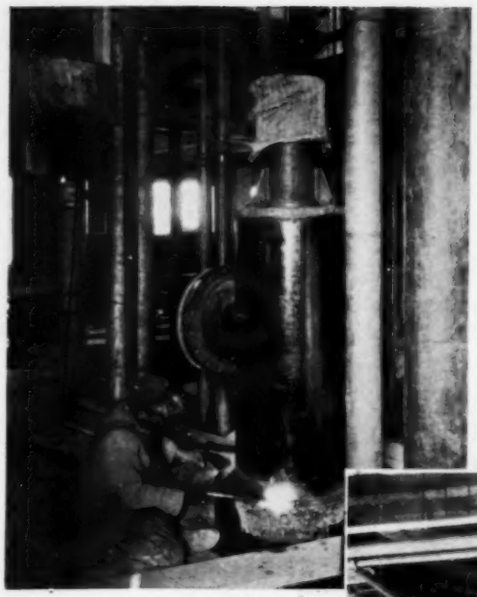
The ceiling line of the railroad varies throughout the entire area, as do the floor levels of the rooms above, and in addition to these the pipe lines slope for the proper gravity flow. These three conditions made a tremendous amount of study necessary for the proper design for installation of these lines. That great care and foresight was used in the locating of these pipes and the fixing of penetrations through the girders is evidenced by the fact that no additional holes were required to be burned at the job after delivering the steel. This steel formation of vertical barriers throughout the entire area necessitated a great number of access doors from the floor above to permit maintenance of the mechanical equipment.

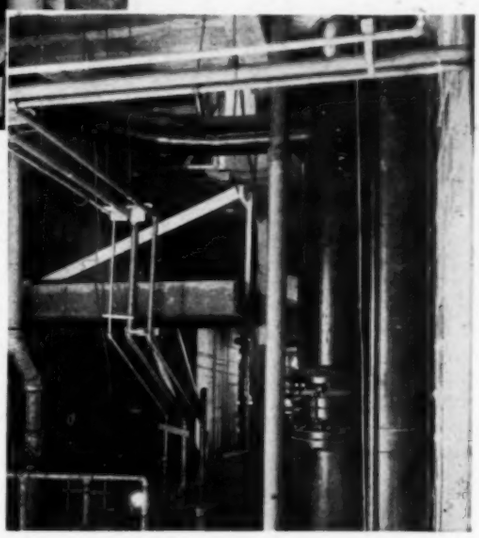
Two-Pipe Vacuum Heating System Installed

The heating system is a regular two-pipe vacuum system, with the numerous horizontal distributing mains supplied from a main riser. Returns are collected and returned to the vacuum and condensate pumps, which discharge through economizers or preheaters to the sewer.

The main steam header carries 125 lb. gage pressure, and is located in the sub-basement. It is supplied by two lines from separate mains outside the building; these leads are cross-connected at the mains and in addition, the header is designed with segregating valves.

There is a small amount of steam-driven equipment which functions as reducing valves to accomplish the necessary drop from 125 lb. to heating pressures. This is supplemented in the customary manner with multiple reducing valves for make-up steam.





ABOVE—WELDING IN THE LARGE REDUCING TEE FOR THE MAIN RISER ABOVE THE 17TH FLOOR, WHERE THE PIPE IS REDUCED FROM A 24 IN. TO AN 18 IN.

RIGHT—MAIN PIPE SHAFT AT 17TH FLOOR. THE EXPANSION JOINT IN THE MAIN STEAM RISER AND DISTRIBUTING MAIN BRANCH CAN BE READILY SEEN

The Main Low Pressure Riser

The heating system in its entirety is designed for low pressure with vacuum return, and the distributing mains are supplied with steam directly from the main low pressure riser. This low pressure riser is a 24 in. pipe carried in the main pipe shaft and runs full size to the 17th floor, where one of the distributing mains is located. From this point to the back pressure valve at the roof the riser is 14 in. However, where the reduction in size occurs there has been provided a blank tee to provide ample exhaust capacity for the installation in the future of the generating equipment.

The reason for the installation of the low pressure risers is to provide for future generators and to keep all reducing valves in the basement.

This main riser supplies all the direct radiation, amounting to about 165,000 square feet, all the steam for the hot water heaters for the building and, in addition, the indirect radiation.

Horizontal Distributing Mains Zone Building

There are three horizontal distributing mains for the heating system, which is, consequently, separated into three zones. The main for the upper or tower section is run on the ceiling of the 43rd floor and from there distributes to the various risers which supply steam to radiators down to and including the 20th floor. Below this point the main building offset occurs. Short return mains are carried in the 19th floor ceiling, which is a service floor, and are dropped down in furred spaces to the next hung ceiling, which is at the 17th floor.

In this hung ceiling the next horizontal supply main is located. This main supplies upfeed risers which feed up to and including the 18th floor and feeds separate downfeed risers which take care of all the other bedroom floors, down to and including the fourth floor.

Collecting the Returns and Drips

The returns and drips are collected on the 4th, 5th and 6th floor ceilings, depending entirely upon the location of the last bedroom floor. Where several returns and drip lines are collected above rooms with special ceilings, return mains were not used but the risers and drips were offset in brass pipe to the nearest storage space or mechanical equipment room, and run into a return header. The valves, dirt pockets and traps are then easily accessible. This is undoubtedly a more costly method, but is certain assurance against a leaky valve or trap ruining an expensive ceiling; it also does away with unsightly access doors. In addition, it has the advantage of accessibility.

The Third Distributing Main

The third distributing main is upfeed and supplies heat to the special rooms and stores in the lower section of the building. This main is perhaps the most interesting of the three, because of its location. As has been explained, the major portion of the building above grade is supported on girders above the New York Central tracks, and it is in this girder space below the ground floor that the steam and return mains run. There are over a hundred girders in this section of the structure.

There is another point about this section which made this work even more difficult. Between the two ends of the building there is a difference in grade elevation of nearly ten feet and consequently the ground floor of the hotel follows the grade, as does the ceiling over the New York Central tracks. The pitch of the mains was then necessarily in the direction of the grade pitch, which brought the drips and returns to the far end of the building where, between the girders, a separate vacuum pump was located to return the condensate to that section of the lot where the sub-basement was located.

Intermediate Pressure Steam Services

Heat balances were worked out to determine the economical division between steam and electric equipment basing them on the hot water requirements. This balance indicated the amount of steam-driven apparatus to install.

There are banks of hot water heaters on the 32nd, 19th, 11th and sub-basement floors which are all supplied steam from the main low pressure riser.

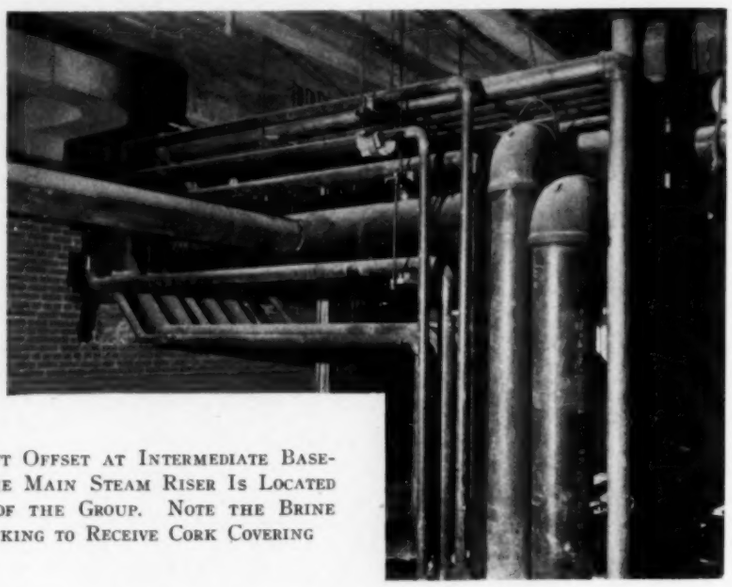
All kitchens, pantries and other rooms having equipment requiring steam at 40-lb. pressure are supplied from a main intermediate pressure riser, which is located in the main pipe shaft. This riser also supplies steam to isolated supply fan rooms where is was uneconomical

to run large size piping from the main shaft, or where architectural features do not permit such runs. A single additional reducing valve in each case is used to bring the pressure down to the customary 5-lb.

Steam to the laundry and valet are supplied at 100-lb. pressure through a single primary reducing valve directly from the main header.

Steam at Header Pressure Confined to Sub-basement

Steam at header pressure is confined to the sub-basement only, and is supplied direct to the steam-driven equipment, namely, the reciprocating refrigeration compressors, air compressors and auxiliary sewage pump.



Main Pipe Shaft Offset at Intermediate Basement Level. The Main Steam Riser Is Located in the Center of the Group. Note the Brine Mains on Blocking to Receive Cork Covering

Provision has been made for leads for the future generating equipment.

Radiation of Conventional Design

A word about the radiators would not be amiss, although there is nothing out of the ordinary either in their design or location. The bedroom floors have copper radiators and all the lower floors where the special rooms are situated are regular cast iron, generally enclosed. Entrance heating is a combination of direct radiation and blast. The radiation for all the main rooms is thermostatically controlled.

The Vacuum Cleaner Piping

The building is to be equipped with a central vacuum cleaning system; because of the difficulty of collecting pipes in the girder space an uplift system was resorted to on the lower floors. The dirt and dust are lifted through the pipes either two or three floors, being collected in headers run in hung ceilings and feeding into one large pipe which is run in the girder space.

Above the third floor, the system is the usual down-feed system, there being sufficient outlets to allow thorough cleaning of the building using fifty feet or less of hose.

There are ten risers which extend the entire height of the building; starting 3-in. in size they are increased as they extend downward, becoming 5-in. on the low level.

In the lower section of the building—up to the 19th floor—are also 21 risers besides the ten main risers. These risers, starting at 3-in. are increased to 4-in. as they extend downward.

The risers are collected into two 10-in. main headers carried to individual separators.

The vacuum cleaner exhaust, which is a 12-in. pipe, is carried through the main roof over the 43rd floor.

A description of the air conditioning and ventilating features of this hotel is to appear in a second article.

Piping for 1000-Degree Steam

Interesting Features of The Detroit Edison Company's Installation

By J. H. Walker*

AT THE DELRAY power plant of The Detroit Edison Co. there is under construction a 10,000 kw turbine installation which will use steam at a temperature of 1000 F. This article describes the piping system which will convey that steam from the superheater to the turbine.

The purpose of this experimental turbine installation is to obtain some experience in the handling of steam at high temperature, so that such steam can ultimately be used on a large scale in power plants. Recent progress in the art of steam power plant design has led to the use of successively higher pressures with corresponding improvements in the efficiency of the thermal cycle. When the initial pressure exceeds 450 lb. per sq. in. or thereabout, with a steam temperature of 750 F, which is the common limit of present practice,[1] it is necessary to reheat the steam at an intermediate turbine stage in order to avoid excessive moisture in the lower pressure stages. Reheating involves the serious disadvantages of increased first cost and operating complications. The use of steam at higher temperatures would permit the employment of the simple regenerative cycle, without reheating, even for very high initial pressures, and the higher temperature would in itself considerably improve the efficiency of the cycle. The Delray experiment is thus a step toward the raising of the temperature limitation which has heretofore existed.

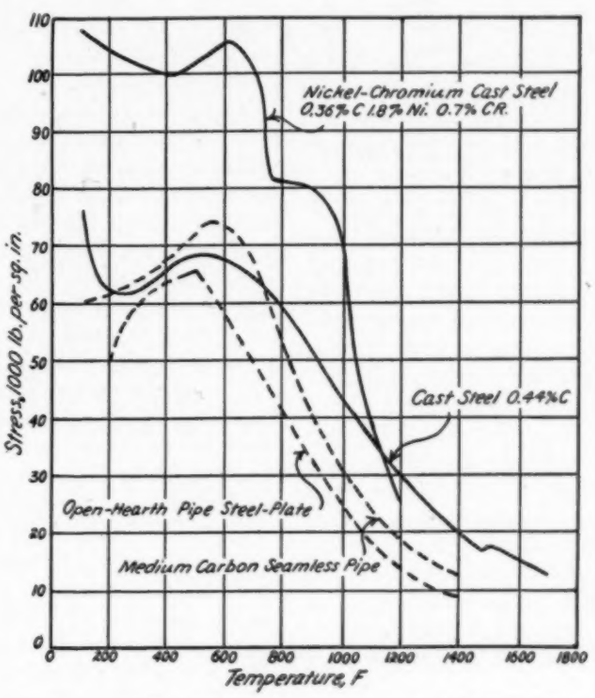


FIG. 1—SHORT TIME TENSILE STRENGTH OF METALS AT ELEVATED TEMPERATURES

Effect of the Increased Temperature

At first thought one might question why an increase in temperature of but 250 degrees above common practice should present any particularly serious problems. There are several reasons why the difficulties increase very rapidly as the temperature is increased above 750 degrees.

The tensile strength of most metals, as indicated by short time tests, drops very rapidly between 700 and 1200 degrees as will be observed from a study of Fig. 1. The strength of cast steel, for example, drops from 62,000 lb. per sq. in. at 750 F to 44,000 lb. per sq. in. at 1000 F, with a consequent decrease in the permissible working stress.

Another factor that must be taken into account is that most metals are definitely plastic at 1000 F and are subject to more or less continuous deformation under stress. Whether or not this plasticity begins at some definite temperature or is present to a less degree at all temperatures may be a debatable question, but there is no doubt of its being present at 1000 F. The design of all parts which are under stress at 1000 F must take this plasticity, or "creep," into account.

A third condition which is met with is the oxidation of the surfaces exposed to steam, and to some extent, to air. There is considerable dissociation of steam and considerable oxidation of ordinary steels at this temperature.[2]

Therefore the handling of steam at 1000 F introduces several new and interesting problems in the design of the superheater, piping, and turbine.

The Turbine Installation

The Delray installation consists of a 10,000 kw turbogenerator with its condenser and auxiliaries, and an oil-fired superheater which will take 700 F steam from the main header of the plant and raise it to 1000 F. The throttle pressure is 365 pounds gage.

The turbine itself is already installed and operating on 700 F steam pending the installation of the superheater and high temperature piping. Some idea of the benefits of increased steam temperature alone may be gathered from the fact that the calculated heat rate of this turbine at its best point, with 1000 F throttle tem-

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[1] There are a very few installations using 850 deg., which appears to be the upper limit with ordinary materials.

[2] See "The Dissociation of Water in Steel Tubes at High Temperatures and Pressures" by C. H. Fellows, *Journal of the American Water Works Association*, October 1929.

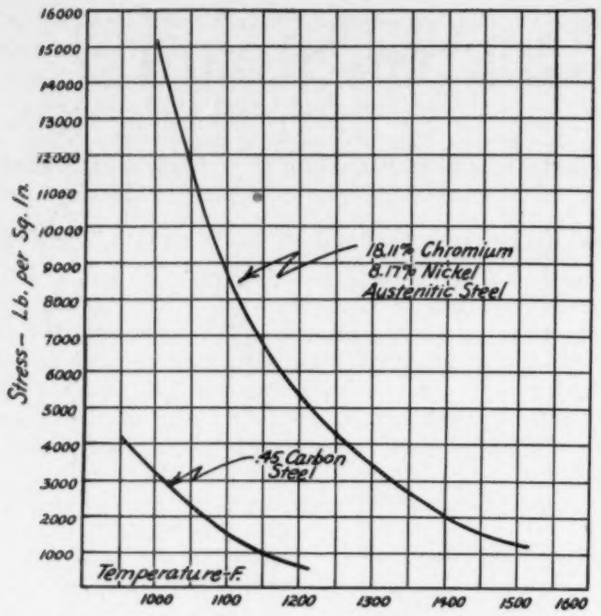


FIG. 2—CREEP STRESS OF STEELS FOR A LIFE OF 100,000 HOURS WITH 1 PER CENT ELONGATION. (VALUES REPORTED BY F. H. NORTON IN HIS BOOK, "CREEP OF STEEL AT HIGH TEMPERATURES," MCGRAW-HILL)

perature, is 10,480 Btu at the throttle per kilowatt hour delivered by the generator, as compared with 11,145 Btu per kwh for the best point of the 50,000 kw main units of the Delray plant operating at nearly the same pressure but at 700 F. This represents an improvement of six per cent and would be greater were the machines of equal size.

The objects sought in the design of the piping for this turbine were, first, to produce an amply safe and reliable installation, and, second, to experiment with various materials and pipe-joint designs so as to obtain information and experience for possible future installations. The piping design embodies some more or less novel ideas because the different behavior of metals at the higher temperature calls for radically different design, in some respects, from that which is common practice.

The Preliminary Experiment

Realizing that difficulties were to be expected the Company installed in 1929, at the Trenton Channel power plant, a small superheater and some piping operating at 1000 F in order to gain some preliminary experience which has been extremely valuable in designing the turbine installation.[3]

Steam at 1000 F is hot steam. It scorches canvas insulation jackets and the clothing of anyone who comes near an unnoticed leak. The jet of steam issuing from a leak is invisible in air because there is no condensation, and leaks must be detected by means of rags on the end of a stick which are set afire by the escaping steam.

There has been considerable trouble experienced in the Trenton Channel set-up due to leaks in the pipe joints. The stretching of the bolts makes it apparently impossible to keep the ordinary flange joint tight for more than a short time. Enough experience has been gained with this preliminary installation, however, to warrant the belief that, insofar as the piping is concerned, the turbine installation can be made reasonably reliable.

[3] A description of this installation is given in the article "1,000 Degree Turbine for Delray No. 3," by J. W. Parker, May 28, 1929, *Power*.

Piping Materials

The most important problem in the design of the piping for the turbine has been the selection of suitable materials, and various alloys have been chosen for the pipe, flanges, and fittings. The material used in the pipe itself must first of all be able to take a fairly high stress without much permanent distortion, so that a thin-walled pipe can be used to give the flexibility that is required for the large amount of thermal expansion which is to be expected. Another important requirement is that the surfaces in contact with the steam be resistant to oxidation.

The material which has been selected for the pipe is an austenitic chromium-nickel steel having the following chemical composition: Chromium, 17.00-19.00 per cent; nickel, 8.00-10.50; carbon, 0.07 max.; sulphur, 0.025 max.; phosphorus, 0.025 max.; silicon, 0.75 max.; manganese, 0.50 max.

This material has been used to some extent in the oil and chemical industries and appears to be satisfactory unless exposed to certain kinds of chemical attack. It is subject to some strain hardening and, upon long exposure to high temperatures, there is a change in its microstructure due to the migration of carbides to the grain boundaries. The deterioration which has taken place in the preliminary set-up after 6400 hours of service is relatively small and the material is still quite ductile and tough. (See Table 1.) It is important, however, that the carbon content be kept very low to avoid the presence of excessive amounts of carbide, which weakens the grain boundaries. No copper must be allowed to come in contact with the metal because certain copper compounds play havoc with its microstructure.

The manufacture of seamless pipe of this material in the size required for the turbine installation (8 in.) had not been attempted before in America. This steel is highly resistant to creep and from that standpoint is quite suitable for the service. It has become the more or less generally accepted practice to compare the creep-resisting qualities of metals on the basis of the stress required to produce a given rate of elongation—as, for example, 1 per cent in 100,000 hours. Fig. 2 shows the comparative values for a steel similar to that used and for an ordinary 0.45 per cent carbon steel. The chromium-nickel steel, for example, will withstand 15,000

TABLE 1—PHYSICAL PROPERTIES OF TUBING AT ROOM TEMPERATURE BEFORE AND AFTER SERVICE[4]

	Similar Material As Received	Specimens from Piping Examined After 6400 Hours at 700 to 1100 F
Tensile strength, Lb./sq. in.	91,600	95,100
Elongation in 8", Per Cent	53	35
Reduction of area, Per Cent	59	36
Rockwell "B" hardness Number	76	80
Izod Impact Value, Ft.-Lb.	97	92

[4] Tests made at room temperature.

lb. per sq. in. at 1000 F, as compared with 3,300 lb. per sq. in. for the plain carbon steel.

Fittings

Materials used in the *fittings* should be resistant to oxidation and be capable of withstanding a reasonably high stress with a small amount of creep. Although it would be perfectly feasible, with the relatively moderate pressure of the Delray installation, to design for very low stresses merely by using relatively heavy sections, it might not be practicable to do so in large high pressure installations of the future because the extremely thick sections then required might not be feasible because of manufacturing difficulties or because of excessive thermal stresses. Therefore, the aim has been to use metals which could safely be subjected to a fairly high stress. Low-alloy steels have been chosen, for the most part, in preference to the more expensive high chromium, high nickel steels. The analyses of some of the steels selected are given in Table 2.

It may be necessary to protect the inner surfaces of these low-alloy fittings against oxidation, either by lining them with a stainless metal as is done in certain of the chemical industries or by coating them in some manner. During the course of the experiment several of these combinations will doubtless be tried.

The Piping Design

Fig. 3 shows the layout of the high temperature piping from the outlet of the separately fired superheater to the turbine. It is not an extensive system, the superheater being located rather close to the turbine.

Referring to Fig. 3, the fittings immediately adjacent to the superheater are cast from the 18-8 chromium-nickel steel. To the smaller outlet of the reducing tee is connected a relief valve, discharging through a vent line to the roof, for the purpose of maintaining a flow of steam through the superheater should the turbine throttle close automatically or require quick closing. If this were not provided for, the stoppage of flow through the superheater would permit it to become overheated even though the oil burners were immediately shut off, due to the heat stored in the furnace refractories. This valve is a solenoid-operated safety valve and is interlocked with the turbine throttle so that it will open automatically when the throttle trips. It can also be opened or closed by a manually operated switch.

Under normal conditions the turbine will be started up with 700 F steam before the oil burners of the superheater are lighted and, conversely, when shutting down the turbine the burners will be turned off and the refractories in the superheater allowed to cool before the turbine is shut down.

The body of the relief valve and the small tee upon which it is mounted will be made of chrome-tungsten steel. The valve trimmings will be of stainless steel.

Adjacent to the tee is a special 10-in. center-pressure globe valve. It has two discs which approach the seat simultaneously and from opposite directions as shown in Fig. 4.

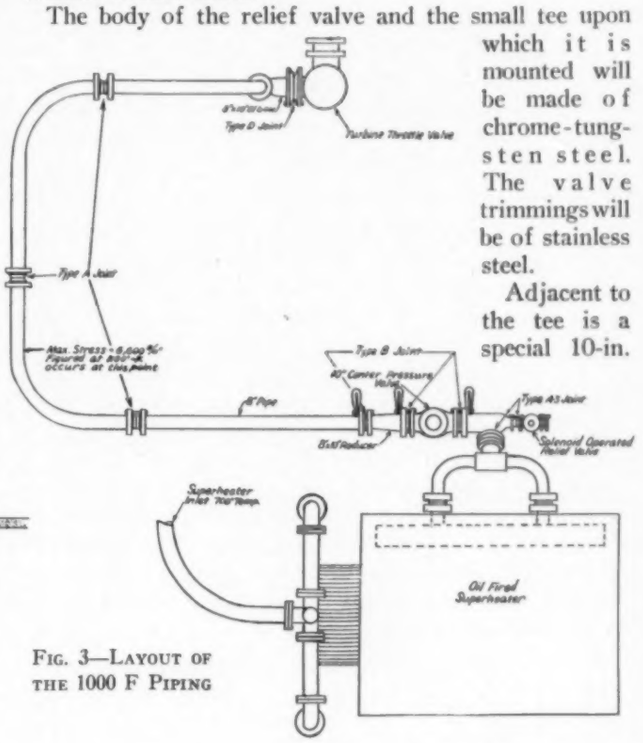
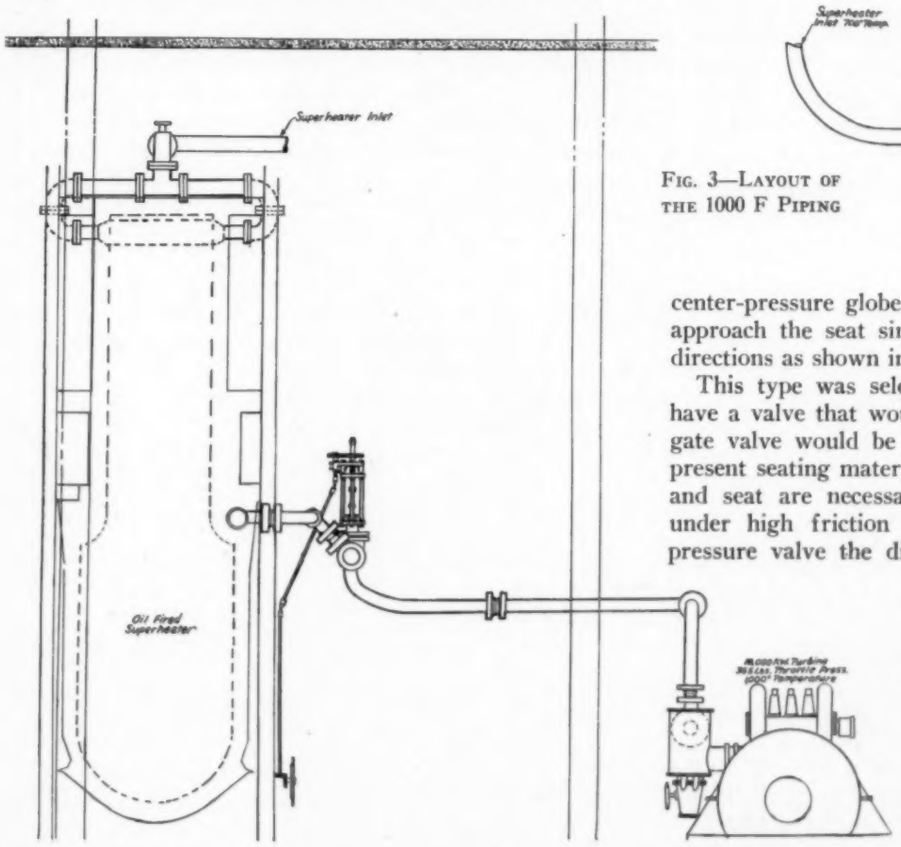


FIG. 3—LAYOUT OF THE 1000 F PIPING

This type was selected because it was desired to have a valve that would surely close tightly, which a gate valve would be unlikely to do at 1000 F with present seating materials. In the gate valve, the disc and seat are necessarily rubbed against each other under high friction pressure, while in the center-pressure valve the discs close against the seat ring without rubbing.

The body of this valve is cast from a chromium-molybdenum alloy. The seat and discs are of a metal whose composition is chosen particularly for high temperature service.

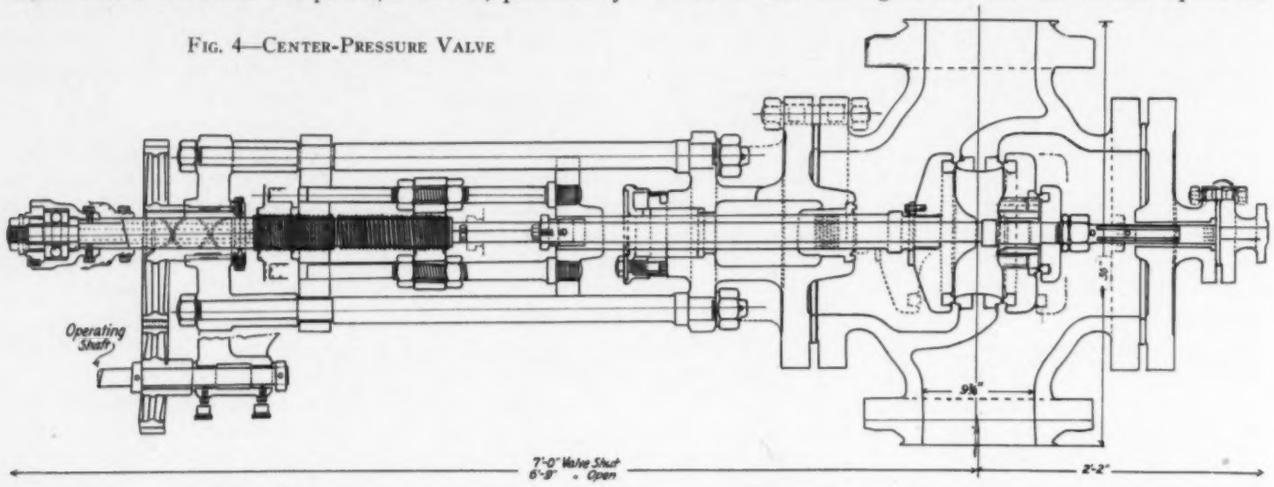
Because it was purchased before the size of the pipe



had been finally chosen, the bore of the valve is larger than that of the pipe and it is necessary to install a reducer between the 10-in. valve and the 8-in. pipe. This fitting will be of a low alloy cast steel, probably containing 0.50 per cent molybdenum.

The dimensions of the flanges and fittings will in general correspond to the 900 lb. W.S.P. American Standard. There are some exceptions, however, particularly in the case of the center-pressure valve whose dimensions correspond to the 600 lb. American standard, and the turbine throttle valve which has an extra large bolt-circle diameter. Also, the fittings forming the superheater outlet have extra thick flanges.

FIG. 4—CENTER-PRESSURE VALVE



The turbine throttle valve is cast from a steel containing 3.10 per cent nickel, 0.25 per cent molybdenum and 0.25 per cent chromium.

The pipe size was originally chosen as 10-in., but when it became apparent that it would be very difficult to obtain seamless pipe of that diameter, the 8-in. size was adopted. The computed friction drop between the superheater outlet and the turbine throttle is 5.3 lb. per sq. in., and the velocity 9,600 feet per minute for full load on the turbine.

Provisions for Thermal Expansion

The coefficient of thermal expansion for the chromium-nickel steel is 10.1×10^{-6} in. per in. per F, which gives, for 1000 F, an elongation of 11.3 in. per 100 feet of pipe. The elongation will be taken care of by the bending of the pipe, which is roughly U-shaped.

In designing for flexibility it was necessary to consider (a) the permissible thrust on the turbine throttle flange as set by the turbine designers, (b) the fiber stress in the pipe wall, and (c) the bending moments at the flange joint. It soon became apparent that the allowable thrust on the turbine throttle (2,000 lb.) would not be approached and that the stress in the pipe wall would be the limiting factor. The maximum equivalent stress, taking into account bursting stress, expansion stress and all other probable stresses, worked out to be 6,240 lb. per sq. in. at the point indicated in Fig. 3.

The question naturally arises as to how the phenomenon of plastic flow should be taken into account in calculating the stress in the pipe wall. It is evident that certain kinds of stresses are slowly relieved as creep takes place. Stress due to thermal expansion results from a definite change of shape of the piping, and as the metal creeps to accommodate itself to the new shape the stress is gradually reduced. On the other hand, stress due to internal pressure is not relieved by creep but is a continuing stress. Advantage can not be taken of this relieving effect in the design, however, because of the time required for it to occur. The stress which exists immediately after the pipe reaches the operating temperature is the stress which should be designed for.

Joints

In the preliminary experiment at Trenton Channel a great deal of trouble has been experienced with flange joints. The bolts elongate under stress, relieving the

TABLE 2—COMPOSITION OF PRINCIPAL MATERIALS USED IN 1000 F PIPING INSTALLATION

	Cast Fittings at Superheater Outlet	Relief[5] Valve	Center Pressure Valve	Pipe	Lose Flanges	Cast Steel Reducer	Cast Steel Reducing Elbow	Bolts
Composition, per cent:								
Chromium	17.0—20.0	5.0—6.0	Composition	17.00—19.00	0.90—1.25	.....	5.0—6.0	1.20—1.40
Nickel	8.0—10.0	.....	not divulged	8.00—10.50	1.50—2.00	.....	.....	.....
Molybdenum	.....	.....	by steel	.....	.....	0.50	.....	.....
Tungsten	.....	0.80—1.25	manufacturer	.....	.....	.....	0.80—1.25	1.75—2.25
Vanadium	.....	.....		.....	.....	.....	.....	0.20—0.25
Carbon	0.25 max.	0.15—0.22		0.07 max.	0.35—0.45	0.25	0.15—0.22	0.45—0.50
Silicon	0.25—0.75	0.50 max.		0.025 max.	.....	.....	0.50 max.	.....
Manganese	0.65 max.	0.50 max.		0.50 max.	0.30—0.60	.....	0.50 max.	0.20—0.35
Phosphorus	0.03 max.	0.05 max.		0.025 max.	.04 max.	0.05	0.05 max.	0.05 max.
Sulphur	0.03 max.	0.05 max.		0.025 max.	.045 max.	0.05	0.05 max.	0.05 max.

[5] Used in the valve body. Disc and seat of stainless steel.

gasket pressure, and leakage takes place, usually commencing when the steam temperature is reduced. Few of the flange joints have remained permanently tight. The trouble is probably due to the bolts being stressed beyond their yield point by the differential thermal expansion of the bolts and flanges. The trouble persists even when the same material is used for the bolts and flanges, undoubtedly because of the considerable temperature differences which exist.

A flange in which the joint is sealed by welding has not been successful because the stretching of the bolts throws a stress upon the sealing weld for which it is not designed.

The piping for the Delray installation will be installed with several different kinds of joints with the idea of eventually developing a satisfactory design. Troubles with gasket joints naturally suggested the use of welding and, since the chromium-nickel steel is fairly easily welded, the lengths of pipe made of that steel will be welded together. However, because of some uncertainty as to the performance of the welds at the operating temperature, the welded joint is backed up by flanges and bolts as shown in Fig. 5 (A-1). The weld is designed to be as strong as the pipe and undoubtedly will stand up satisfactorily, but the bolts would hold the pipe together in case the weld should completely fail. The bolts doubtless will stretch until the stress in them is very low and will remain in that condition.

The loose flanges bear against a ring which is screwed to the pipe and welded, this construction being adopted because of the difficulty of forming the ends of the chromium-nickel tubing into a similar shape. The ring is of the chromium-nickel alloy but the loose flanges, because extremely high creep resistance in their case is not important, will be of a low-alloy steel.

A similar joint with cast-on flanges will be used to connect certain fittings, near the superheater, which will not require disconnecting from each other. Fig. 5 (A-3).

This form of welded joint can not readily be used with valves and fittings of commercial design, nor can it be readily broken and remade. Since it is important that some form of flange joint be developed which is not open to these objections, the form shown in Fig. 5 (B) will be tried in certain locations. Its peculiar feature is the hair-pin spring under the nut, which is designed to compensate for the apparently unavoidable stretching of the bolts. The spring is of a high grade spring steel and is so designed that a stretch of the bolts of 0.10 in. will decrease the gasket pressure but 20 per cent. The springs will be left un-insulated and will therefore retain their elastic properties. Experience has shown that, if left uncovered, their temperature will not exceed 500 F.

A third form of joint which is also rather interesting is that shown in Fig. 5 (D). It was designed in England and is used at the turbine throttle valve. The flange is enlarged to give a large bolt circle and the bolts will be left uninsulated and will consequently not reach a high temperature. A recessed composition gasket will be used.

Naturally some difficulties are anticipated with the joints and these are not necessarily the final designs which will be adopted.

Insulation

The pipe will be covered with 4½ inches of insulating material of which the inner 3 inches will be of a heat-resisting type, probably containing a large percentage of diatomaceous earth, and the outer 1½ inches of 85 per cent magnesia. The insulation does not involve any particularly difficult problem except that there may be some deterioration of the material immediately adjacent to the pipe wall.

The materials to be used for the various parts of the piping system are shown in Table 2. Creep tests are being made in the laboratory upon the various kinds of metal and an attempt will be made to coordinate laboratory creep data with actual field experience. Such coordination is greatly needed. We do not know, for example, whether the use of stresses which in the laboratory will produce elongation at the rate of one per cent in 100,000 hours is correct for practical design or whether a higher or a lower stress should be employed. Provision is therefore being made to take periodic measurements of the valves, fittings and pipe to determine exactly what distortion takes place. Similar data will be obtained for the turbine and superheater.

It is unlikely that any insurmountable problems will arise. It is to be expected that many of the extreme precautions taken in this experimental installation will be found to be unnecessary and that subsequent installations will be simpler, less expensive, and therefore more commercially justifiable.

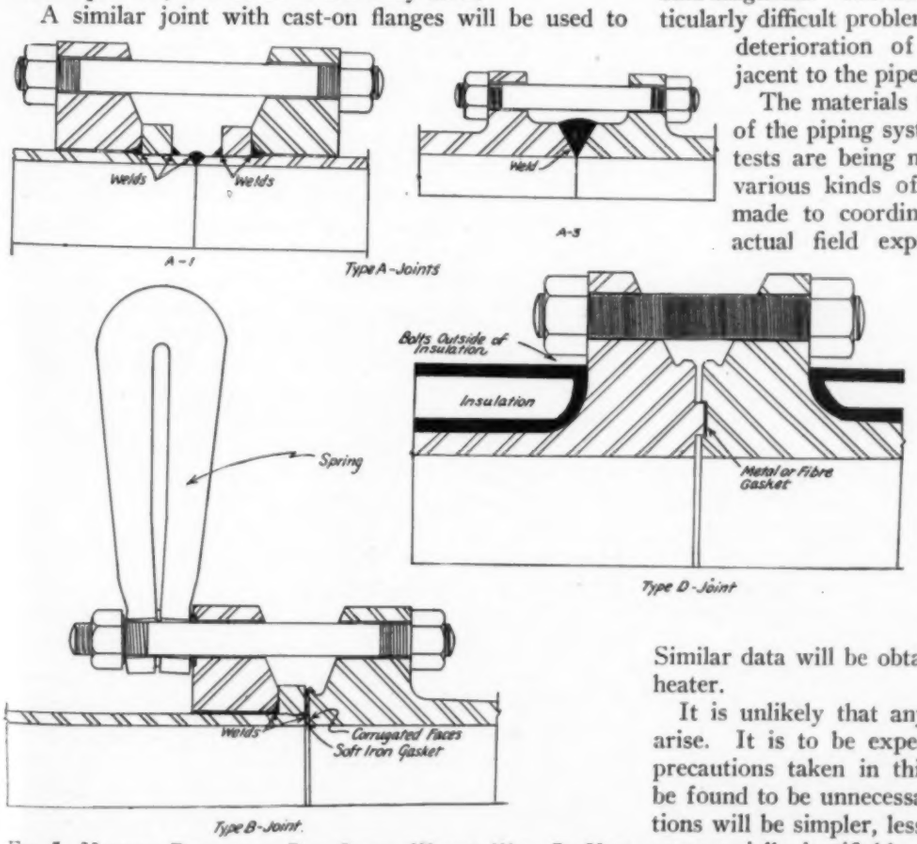


Fig. 5—Various Designs of Pipe Joints Which Will Be Used

Heating and Air Conditioning Must Be Carefully Considered in Design of Buildings

By Mortimer Freund*

It is much more satisfactory—and much less expensive—to make adequate provision for the installation of the heating and air conditioning systems in a building in the initial design. Changes and alterations are costly, and are generally made at a sacrifice of other desirable qualities.

Close co-operation of the architect and the structural engineer with the heating and air conditioning engineer aids in the proper design of buildings of all types. The result is a better building, a satisfied owner, and an important reduction in cost.

Mr. Freund's article is well-worth the careful study of every architect, structural engineer, and heating and air conditioning engineer.

IN MANY buildings constructed during recent years, to say nothing of older buildings, too little consideration has been given by those responsible for their planning to the requirements and the accommodation in the structure of the necessary mechanical and electrical equipment. To those who have financial interests in the construction and operation of buildings this fact should be a matter for grave concern, for it should never be forgotten that, although the cost of installation of the heating, air conditioning, plumbing, sprinkler and other mechanical systems, the electrical equipment and the elevators, represents a comparatively small part of the total initial cost of the building, the operation of these systems, together with their maintenance and repair, constitutes a large proportion of the total annual cost of operating the building and of making it of service to its occupants and to its owner. Building managers and superintendents are quite well aware of this.

Designer Must Know Practical Limitations

It is obviously necessary that the designer of the heating and the air conditioning systems be fully acquainted not only with the principles which govern the heating and air conditioning of buildings, but also with the application of these principles under the limitations imposed by the practical considerations of building construction. It does not follow, however, that men who are capable of installing such systems according to plans and specifications are capable of designing them, any more than it follows that those who are capable of designing such systems can perform with skill the work of actual installation. These are facts which are frequently lost sight of and are sources of both installation and operating difficulties.

Desirable Qualities in Buildings Must Be Balanced

In designing a building not only beauty and harmony, but also utility and efficiency must be considered fully. Efficiency involves both low cost of maintenance and low cost of operation after the building is in use. It is rarely possible to secure all of these in the highest degree. Usually, sacrifices must be made at the expense of one or more of these and the architect, upon whom such decision must naturally rest, should weigh all factors carefully and exert his skill in design to secure beauty and harmony without destroying utility and efficiency.

Architect and Engineer Should Be in Close Touch

For this reason, the architect should avail himself of competent advice concerning the design of the mechanical and electrical equipment. It is not to be expected that an architect can be fully conversant with the details of design of all of the features which enter into the construction of a modern building, but it is to be expected that his plans be based upon an intelligent understanding of the requirements.

In order that a building may be pleasing to the eye, as well as useful and efficient, it is of the utmost importance that all of the features entering into the mechanical and electrical equipment, as well as the structural features, should be given proper consideration from the initial to the final stages of design. The consulting engineer or engineers should be selected while the preliminary architectural drawings or sketches are being made, and the architect and the engineer should be in close conference at this time. Many an unsightly and discordant effect in a completed building could have been avoided, if the architect had known at an earlier stage that a pipe or a ventilating duct had to be located in a particular place, if he had provided adequate shafts for pipes and ducts, or if the steel framing had been planned to permit the passage of pipes or ducts in the manner in which they must be run so as to function properly.

There are many features in heating and air conditioning systems, such as position of risers and radiators, the size, shape and location of ducts and registers, and others, which are intimately connected with the decorative treatment. Not only does the careful consideration of such things distinguish the truly

* Eadie, Freund and Campbell, consulting engineers, New York City.

competent architect from the architect who sacrifices every other consideration to outward appearance, but it also reduces to a minimum changes during construction and the attendant extra charges, those much-to-be-avoided sources of disagreement and friction between architects, engineers, contractors and owners.

Advantages of Frequent Conferences

Probably the primary source of most installation and operating troubles in connection with heating and air conditioning systems is the failure to consider the requirements of such systems when the architectural and steel framing plans are being developed. The consulting heating and air conditioning engineer should be selected almost as soon as the architect is selected. He should be in frequent conference with the architect and the owner or tenant for whom the building is being constructed. He should be informed as to the use to which various parts of the building are to be put and to the decorative effects which the architect is striving to secure. At such conferences the consulting engineer, in the light of experience gained in other projects, will exchange ideas with the architect and offer suggestions regarding heating and air conditioning methods and equipment for the consideration of the architect and other interested parties. He will then proceed to design these systems, giving the architect and the structural engineer such information, either in the form of reports or of sketches, as to enable them to incorporate in their plans the necessary provisions to accommodate the equipment, pipes and ducts.

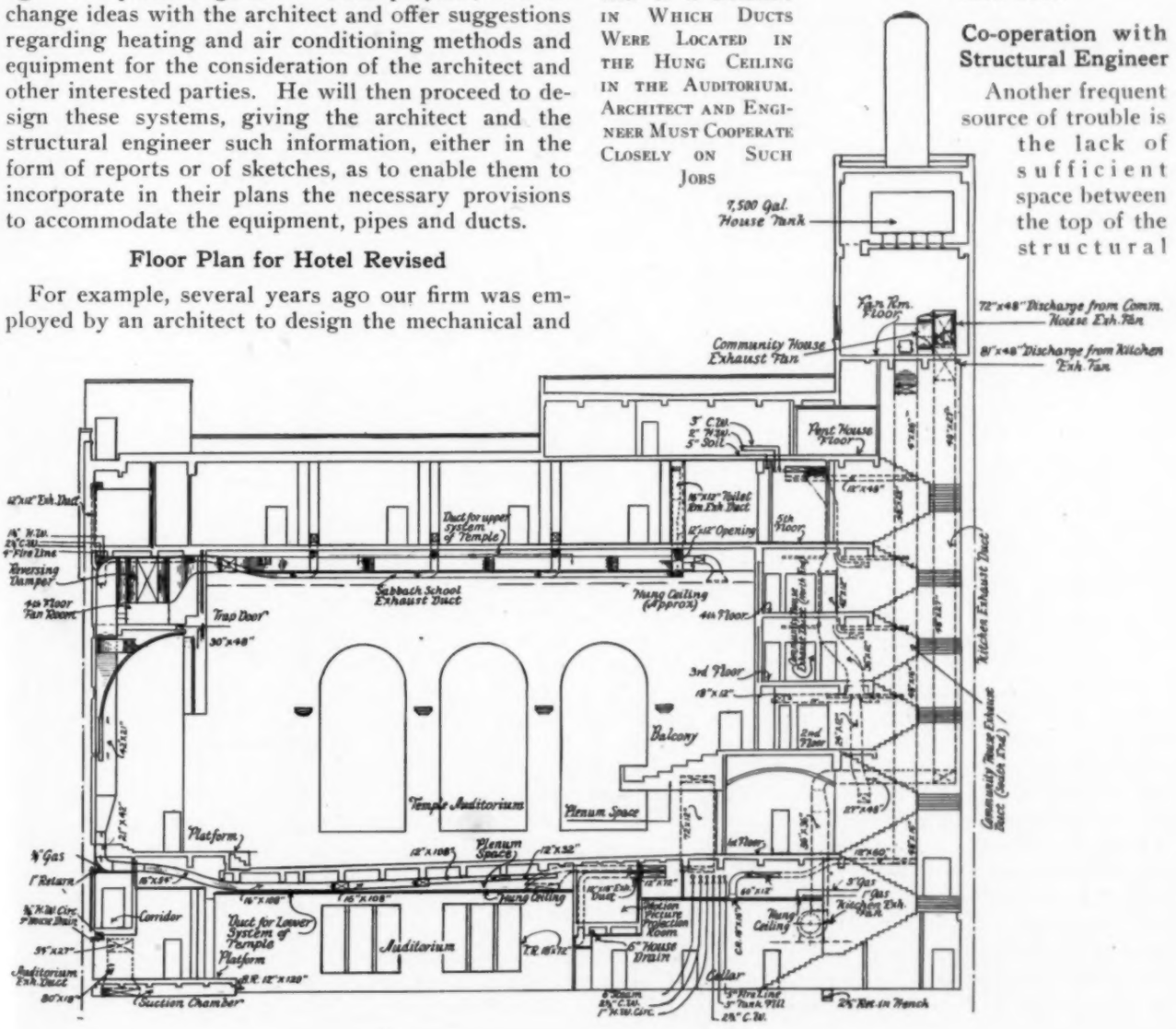
Floor Plan for Hotel Revised

For example, several years ago our firm was employed by an architect to design the mechanical and electrical equipment for a large hotel. A plan was handed to us showing on the typical floor approximately thirty apartments consisting of one, two and three rooms with bathrooms and serving pantries. Some masonry ventilating shafts were shown, but not of sufficient number or size to take care of all of the bathrooms, pantries and corridors, nor was sufficient space allotted for the water and drainage pipes. It was necessary for us to design a new arrangement of rooms for this floor, allowing for the necessary pipe and duct shafts. This was submitted to the architect, approved and adopted by him and the building was built accordingly.

Running Pipes in Ventilating Ducts

At this point it may be well to note that a frequent cause for the ineffective operation of ventilating systems is the use of unlined vertical masonry ventilating shafts in which vertical water and drainage pipes are run. Very frequently the effective cross-sectional area of such a ventilating shaft is greatly reduced and even entirely destroyed due to the horizontal branches from such vertical pipes to the plumbing fixtures at each floor.

A Longitudinal Section of a Building in Which Ducts Were Located in the Hung Ceiling in the Auditorium. Architect and Engineer Must Cooperate Closely on Such Jobs



Co-operation with Structural Engineer

Another frequent source of trouble is the lack of sufficient space between the top of the structural

steel and the finished floor for concealing branch connections to radiators, where this is a requirement. Where sufficient space is not provided, trouble may be expected from the inability of radiators to drain freely and from breakage of fittings. Adequate floor fill must be insisted upon during the early stages of design, as it is practically impossible to have this changed at a later date, for the addition of floor fill affects the design of the steel framing and also the clear height from floor to ceiling.

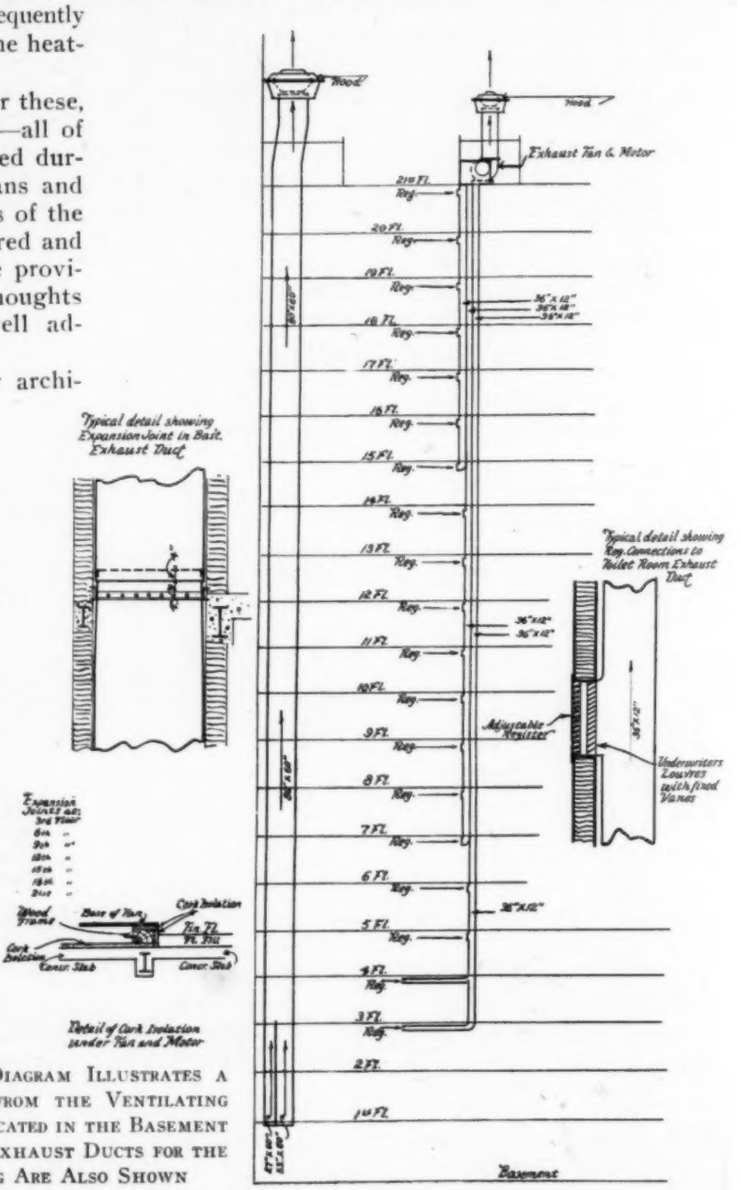
If flanges of structural steel members are to be cut away to permit of passage of radiator branches, the location and size of such cuttings must be given to the structural engineer and noted on his drawings, for cutting in the field is more costly than cutting in the shop and furthermore tends to delay the progress of construction. Where the structural engineer is designing in conference with the heating and air conditioning engineer, slight changes in the depth of beams, or the lowering of a beam one or two inches frequently simplifies an otherwise difficult problem for the heating and air conditioning engineer.

The location of ducts, the clear height under these, the size and location of registers and grilles—all of these—are matters which should be considered during the development of the architectural plans and details. Only too frequently the effectiveness of the heating and air conditioning systems is impaired and the appearance of a room is marred because provisions for these systems have been after thoughts when construction of the building was well advanced.

An important point to be remembered by architects, engineers, contractors and all others engaged in the heating and air conditioning industry is that the design of heating and air conditioning systems is not simply a matter of establishing the amount, type and distribution of radiating surface, the sizes of pipes, ducts, registers, fans, etc., but it is the weaving of these systems into the structure of the building. These systems should be designed with regard to the other systems of mechanical and electrical equipment so that there will be no interferences in location of pipes and equipment and so that a maximum economy of operation of the entire mechanical and electrical installation may be secured. For this purpose, close cooperation between the architect and the consulting engineer is necessary, and for cooperation mutual tolerance and understanding are necessary. The old plan of letting the plumbing contractor lay out his own piping, the steamfitting contractor his piping and the sheet metal contractor his ducts, with the contractor first at the job installing with utter disregard of the requirements of the others, results only in delayed progress, in costly changes and in unsatisfactory and uneconomical operation.

Superintendence During Construction

This leads to the matter of proper superintendence during the construction period. In the case of a large apartment building recently erected, in which the rental values are high, great care was taken in the planning of the building to insure high ceilings in the rooms. With this end in view cuts were provided in the steel for the passage of radiator branches. The owners, to save expense, declined to engage either the architect or the engineers to supervise during the construction period. One result was that the radiator branches instead of being run in the floor fill, were run at the ceiling below and the steamfitters made no effort to hold these branches as close to the underside of the floor construction as possible. This condition was not noted until late in the job. In order to conceal these branches hung ceilings had to be installed at considerable cost, reducing the clear



This Ventilating Riser Diagram Illustrates a Vertical Exhaust Duct from the Ventilating System of a Restaurant Located in the Basement of a Tall Building. The Exhaust Ducts for the Toilets in the Building Are Also Shown

height in the rooms and thus nullifying the highly desirable effect for which extra money had been expended.

Provision for Future Ducts

Another consideration is the importance of complete air conditioning, or at least provision for future installation of air conditioning systems to create rentable space in buildings. It is not so long ago that the installation of restaurants, cafeterias and their kitchens in the basements of buildings was practically not to be considered, because it was essential that no odors from cooking should be transmitted to the upper stories of the building. Even today such a clause against transmission of odors is usually placed in the lease of a restaurant tenant. Due to the provisions of ample ceiling height in such basements and of adequate shafts for vertical ducts, vast basement areas in large buildings have become rentable area bringing large additions in revenue to the owner of the building.

One of the first considerations of the prospective restaurant tenant must be the availability of space for necessary ventilating ducts and many a lease has failed to be consummated because of the impossibility of carrying vertical ducts up through the building. If such vertical ducts are installed during the construction of the building, the cost of their installation is greatly reduced and the connection to them when the basement space is leased is a comparatively simple matter.

Shafts Obstructed

The necessity for careful planning of ventilating shafts and careful supervision of their construction can be well illustrated by the case of a combination office and theater building in a large city. The tenant who leased the basement for restaurant occupancy was shown the opening near the ceiling of the basement into a large shaft, which, he was told, ran to the roof and was available for his use. After his ventilating system was installed, the exhaust fans failed to remove the required amount of air and built up a high pressure. Finally a man managed to enter the shaft and found that it had a horizontal offset between the second and third stories and, on cutting into it from above, found that the shaft was practically completely blocked because a partition had been carried across the offset during construction. It was also found at one point that part of a floor arch projected into the shaft and at several points structural members crossed the shaft and seriously reduced the effective cross-sectional area.

It was also noted that odors frequently entered the theater and the theater tenant threatened suit, as the attendance was considerably reduced. Investigation developed the fact that, when the organ was installed in the theater some years before, the theater tenant's contractor had broken into the wall of the shaft when installing the wind trunk and had failed to patch up the openings, thus leaving a large opening from the shaft into the theater.

All of this trouble, with the attendant losses of time and revenue—also the frequent losses of temper on the part of those involved—could have been avoided, if sheet metal ducts, carefully designed and carefully installed, had been provided when the building was constructed.

Improper Design a Heavy Penalty

It can not be repeated too often for the benefit of those financially interested in the construction of buildings, as well as for the benefit of those who design buildings, that improper design of heating and air conditioning systems and inadequate provision for their accommodation in the building structure entail not only additional installation charges but also additional operating costs and that the latter repeat year after year during the life of the building.

Note: Acknowledgement is hereby made by the writer to J. G. Eadie and J. K. Campbell for their assistance in preparing this article.

A. S. T. M. Committees Meet

At a meeting held March 16, committee *D*-5 on coal and coke, of the *American Society for Testing Materials,* voted to advance to standard the present tentative method of test for size of anthracite. The only change to be made in the method is a more definite location of points of sampling in case samples must be collected from tops of railroad cars.

In co-operation with committee *D*-2 on petroleum products and lubricants and the power test code committee of the *American Society of Mechanical Engineers,* the committee will undertake the preparation of definitions of "gross calorific value" and "net calorific value" of fuels. Gross calorific values are those obtained by burning fuels in bomb calorimeters, and net calorific values are those actually obtained when fuel is burned under atmospheric pressure as in most industrial furnaces. The net calorific values are especially important in comparing heating values of fuels.

A proposed tentative method of sampling coke for analysis was presented for discussion. It will, however, not be recommended to the society as a tentative standard until it has been more thoroughly tested.

Research Committee on Fatigue of Metals

The committee decided to start the preparation of a statement of the present day knowledge of the failure of metals under the simultaneous action of repeated loading and corrosion, which is a very serious problem; and to prepare a statement of the significance of results of "fatigue" tests under repeated loading for the structural engineer, the machine designer, and the makers and users of boilers, tanks, oil stills, etc.

Dr. F. F. Lucas, a member of the committee, showed photomicrographs at very high magnification showing the formation of incipient cracks in steel hardened in certain ways, and the chairman, Prof. H. F. Moore, briefly presented a statement of preliminary test results on the relative damage done by a given stress at the surface of a metal, and by the same magnitude of stress below the surface of a metal.

The accumulator is an important part of the high pressure process steam piping system in the plant of the Waldorf Paper Products Company. Mr. Edeskuty describes the function of this piece of equipment, how it is controlled and how its value as a part of this piping system was estimated. How the capacity of the accumulator was determined is also discussed.

In last month's HEATING, PIPING AND AIR CONDITIONING (the March number), Mr. Edeskuty told how the piping in this plant was arranged, how the sizes were calculated and showed a heat flow diagram. His article this month completes the description of this interesting high pressure job. Large economies were effected by re-designing the plant.

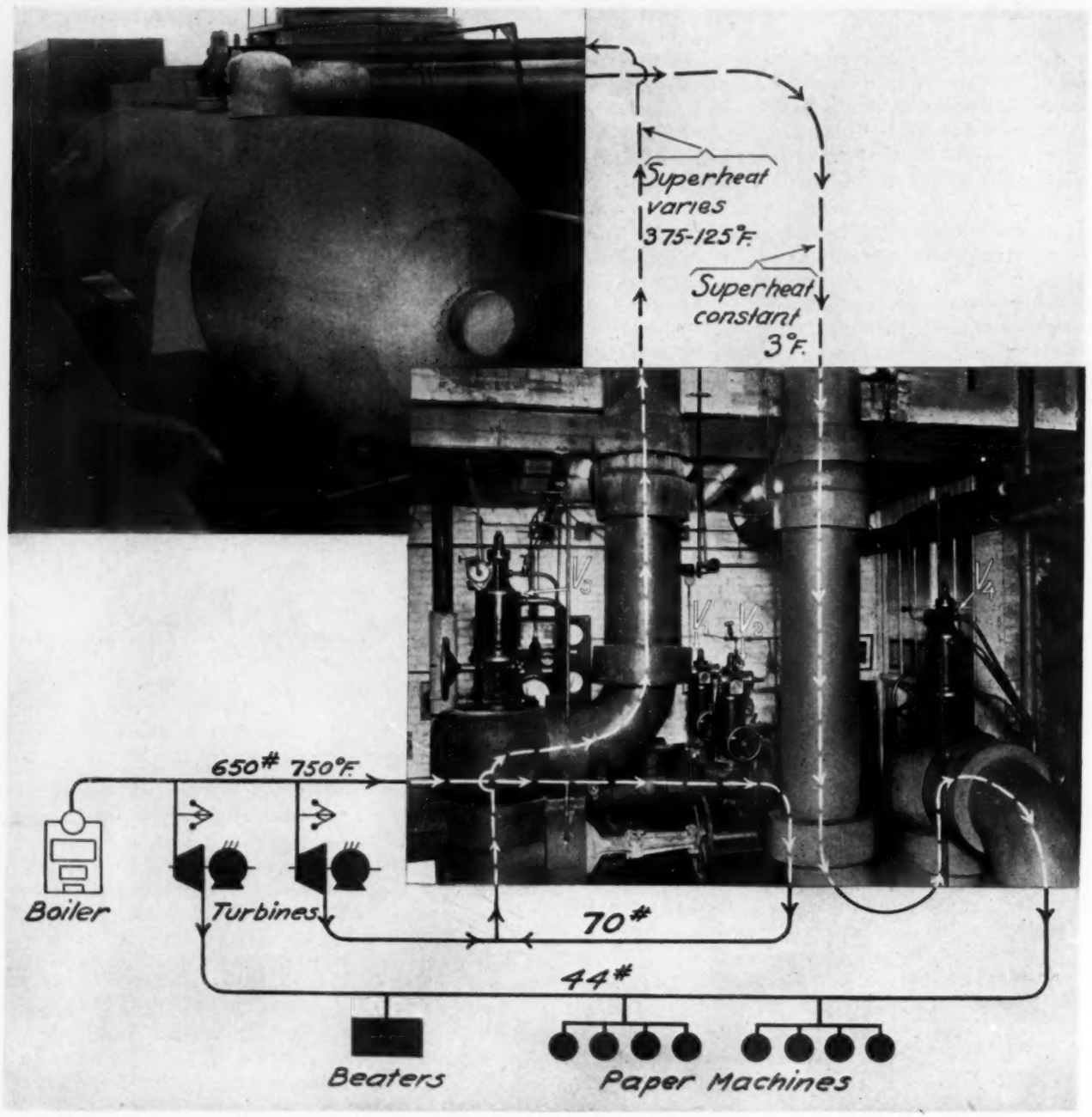


FIG. 1—A STEAM FLOW DIAGRAM FOR THE ACCUMULATOR

Piping an Industrial High Pressure Plant—Electric Power and Process Steam Loads Balanced

By J. V. Edeskuty*

A SHARE of the credit for the successful operation of the plant is due the steam accumulator, which is illustrated in Fig. 1. It serves as a load balancer by storing the turbine exhaust steam when the amount of steam necessary for generating the required electric energy is greater than the process steam demand and by releasing low pressure steam under the reverse condition.

In this manner the load on the boiler is kept uniform and the pressures of the boiler and the process steam are practically constant. When the accumulator, after fifteen months' continuous operation, was taken out of service for inspection, cleaning and some minor repairs, the boiler load fluctuated considerably, the boiler pressure varying more than 90 pounds per square inch and the process steam pressure about 10, and the average boiler efficiency dropped from over 86 per cent to 83 per cent. With the accumulator, the fluctuations in the boiler pressure are so small that, instead of operating the boilers with a drum pressure of 635 pounds gage, it has been found possible to operate them with an average drum pressure of 646 pounds gage, or within four pounds of the pressure for which the safety valves are set.

Besides fulfilling the functions of a load balancer and pressure regulator, the accumulator serves as a desuperheater and to some extent as a feed water evaporator.

The success of the accumulator is largely due to the regulating equipment which consists in the Waldorf Paper Products Co.'s installation of four sensitive valves, supplied with the accumulator. There are two 3-in. valves acting as overflow, reducing and limit pressure valves between the boilers and the accumulator; one 12-in. valve acting as an overflow, reducing and limit pressure valve between the turbine exhaust and the accumulator, and one 14-in. valve in the discharge line from the accumulator, acting as a reducing valve and maintaining a constant pressure in the mill header. A schematic view of the last named valve is shown in Fig. 2, and its action can be described as follows:

Control of the Accumulator

The valve is a double disc balanced valve V and is opened or closed by a motor which is operated by oil pressure. This oil pressure is supplied by a small pump and is controlled by a pilot valve P and relay R, which in turn are actuated by the pressure in M to be regulated.

An increase in the process steam demand will momentarily reduce the pressure in header M. This deflects the disc D to the right. The rod R and the spring loaded lever L, with fulcrum at F, follow this movement and reduce the opening in the overflow port O. A continuous stream of oil flows through this orifice and the rate of flow can be adjusted with the throttle valve T to suit conditions. As the area of the orifice is reduced, the pressure in chamber C_1 is increased, forcing the pilot valve P down. Oil is admitted to chamber C_2 and the valve V is opened wider.

The increase in the oil pressure also acts on the under

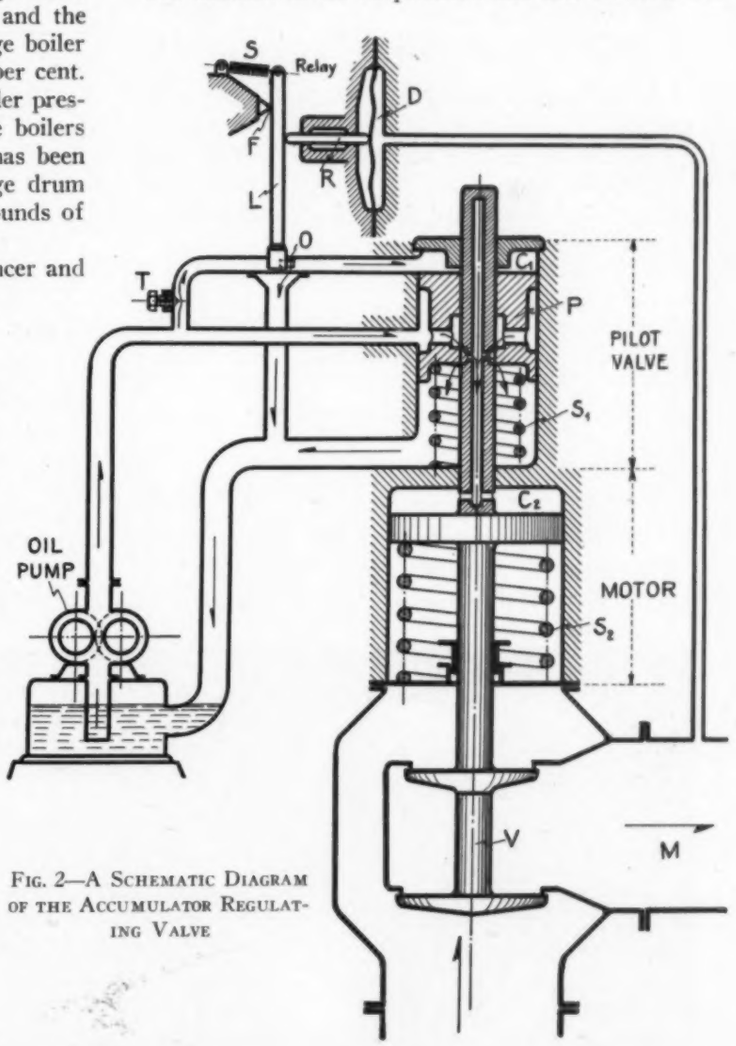


FIG. 2—A SCHEMATIC DIAGRAM OF THE ACCUMULATOR REGULATING VALVE

* Engineer, Ralph D. Thomas and Associates, Minneapolis.

side of the piston of valve P, returning it to its original position and bringing the motor and valve V to rest in their new position. The springs S_1 and S_2 serve to raise valves P and V when the operation is reversed. The valve can be operated by hand with the wheel, and it can be instantly closed by an emergency trip lever. The time for full stroke can be varied from 1/5 to 60 seconds. This adjustment is necessary when there are several valves operating in parallel with each other or with a turbine governor.

If the orifice O is placed to the left of the lever L, the valve will act as an overflow valve. By adding diaphragms acting on the same lever, but actuated from various sources, several functions can be combined in one valve as has been done in the case of the 3-in. and 12-in. valves.

Estimating Value of Accumulator

The value of the accumulator was estimated as follows:

Yearly operating cost with accumulator:

Assuming an average pressure in the accumulator of 57 lb. gage, an average outside temperature of 45 F, the heat loss from the covered accumulator will be

Inside temperature for 57 lb. gage..... 304.5 F
Outside temperature ..... 45.0 F

Temperature difference ..... 259.5 F

Surface area of accumulator, including piping = 3,500 sq. ft.

Heat loss per square foot of bare surface = 783.4 Btu per hr.

Total heat loss from bare accumulator, $3{,}500 \times 783.4 = 2{,}741{,}900$ Btu per hr.

Efficiency of double standard thick 85 per cent magnesia assumed as 94.7 per cent.

Heat loss from covered accumulator, $2{,}741{,}900 \times 0.053 = 145{,}420$ Btu per hr.

Total heat loss per year, $145{,}420 \times 8{,}760 = 1{,}273{,}879{,}200$ Btu.

Fuel cost for this with coal of 13,500 Btu as fired, $6.00 per ton in the furnace and an average operating efficiency of 86 per cent.

$$\frac{1{,}273{,}879{,}200}{13{,}500 \times 0.86 \times 2{,}000} = 55 \text{ tons @ } \$6.00 = \$330.00$$

Cost of accumulator installation, $55,000.00.

Fifteen per cent overhead, $8,250.00.

Cost of fuel based on average daily production of 225 tons of paper working days:

110,000 lb. of steam per hour for 7,200 hours..... 792,000,000 lb. of steam
65 Sundays and holidays @ 300,000 lb. ..... 10,500,000 lb. of steam

Total steam generated per year 811,500,000 lb. of steam

Fuel cost for this:

Heat of steam at superheater outlet..... 1,372 Btu
Heat in feed water..... 222.5 Btu

Heat absorbed in boiler per lb. of steam.. 1,149.5 Btu

$$\frac{811{,}500{,}000 \times 1149.5}{13{,}500 \times 0.86 \times 2000} = 46{,}173 \text{ tons @ } \$6 = \$241{,}038$$

Total annual operating cost of boiler plant, exclusive of labor and boiler room overhead $249,618

Yearly operating cost without accumulator:

Installation cost of additional 1,000 boiler horsepower @ $119..... 119,000
15 per cent overhead..... 17,850

Cost of fuel:

Total steam (as before) = 811,500,000 lb.
Operating efficiency, 83 per cent.

$$\frac{811{,}500{,}000 \times 1149.5}{13{,}500 \times 0.83 \times 2000} = 41{,}625 \text{ tons @ } \$6 \ldots \$249{,}750$$

Total annual operating cost of boiler plant with overhead on that portion of plant replacing the accumulator and exclusive of labor... $267,600

Saving to be credited to accumlator:

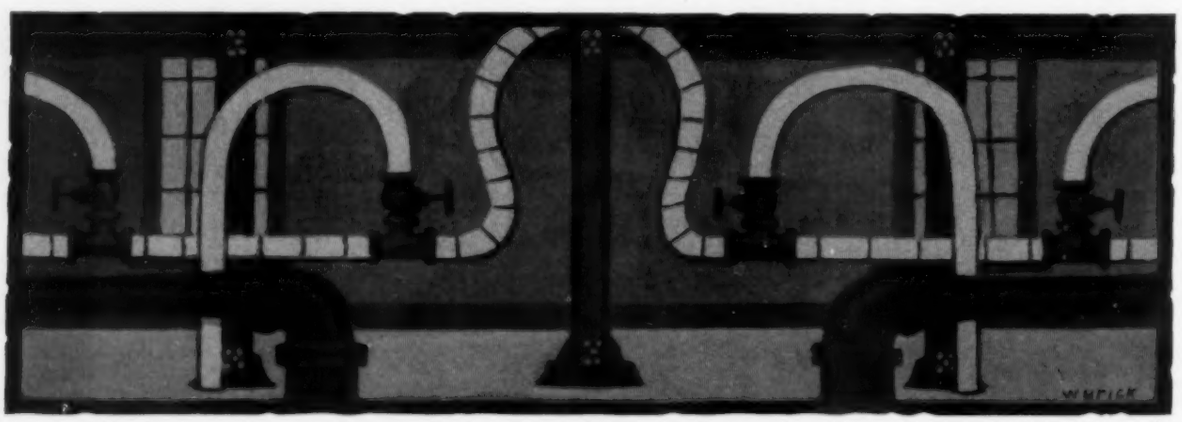
($267,600 — $249,618) = $17,982

This saving does not include such benefits as instantaneous standby, constant steam conditions and no spoiled product because of insufficient and varying dryer pressure.

Calculating Capacity of the Accumulator

With the present output one boiler only is used to supply the required steam demand. Should it become necessary to shut this boiler down instantly, the accumulator in conjunction with a small low pressure condensing turbo-generator can be made to serve.

By a coincidence of circumstances it may be possible that the boiler must be taken out of service with the accumulator at a minimum pressure of 44 pounds gage.



Assuming that the low pressure turbine will take steam at the throttle at a pressure of 20 pounds gage and that the condenser will produce a vacuum of 2 in. absolute, we have:

Storage capacity of the accumulator:

The heat of liquid of one pound of water at 44 pounds gage pressure is 260.5 Btu and the temperature is 290.2 F. One cubic foot of water at 290.2 F weighs 57.73 lb.

Total heat per cubic foot = $260.5 \times 57.73 = 15{,}039$ Btu.

When the pressure is reduced to 20 pounds X pounds of water will flash into steam while $(57.73 - X)$ pounds remain in liquid form.

Total heat of steam at 20 lb. gage = 1,166.5 Btu.

Heat of liquid at 20 lb. gage = 227.2 Btu.

Therefore,

$1{,}166.5 \times (57.73 - X)\ 227.2 = 15{,}039.$

$X = 2.05$ lb. storage capacity per cubic foot of water.

Total storage capacity, $9{,}600 \times 205 = 19{,}600$ pounds.

The power required for auxiliaries when starting up, together with the necessary lights amounts to 350 kilowatts.

The water rate of the turbine at this load is 27.5 lb. per kw-hr.

Steam consumption of turbine per hour = 9625 lb.

There is sufficient capacity in the accumulator to operate the turbine at this load for $\frac{19600}{9625} = 2$ hours.

In this time the other boiler can be started.

Air Conditioning Used to Increase Prestige and Attract Patronage

By Louis L. Narowetz, Jr.*

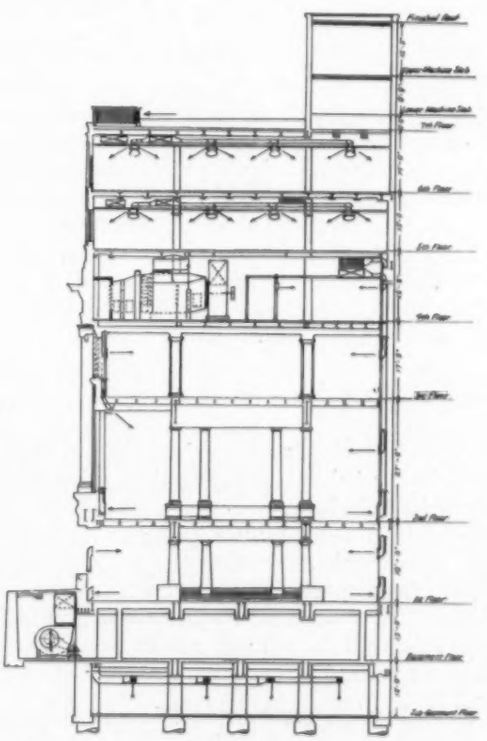
THE Northern Trust Company bank building, located at LaSalle and Monroe streets, for years an outstanding structure in Chicago's financial district, was completely modernized a few months ago and two stories were added to the existing four-story building. The design in some particulars is rather unusual. The entire fourth story has no windows, and for this reason special engineering was necessary in order to provide satisfactory air conditioning. This installation is unusual also because of the object of the air conditioning, which is, according to a statement from the owners of the building, to increase the prestige of and attract patrons to the bank. It is also unusual on account of the windowless feature, which has been discussed by various engineers in recent months. For these reasons it is believed that the description which follows will be of more than ordinary interest to air conditioning engineers.

When the original building was erected some twenty-five years ago, the consulting engineers, Neiler, Rich & Company, designed the ventilating system. They are also the designers of the present air conditioning system. The original ventilating system was designed on the basis of four changes of air per hour. The air was introduced on blank wall opposite the windows with the idea that the window side of the building would take care of its own ventilation to a certain extent. This is a good example of the change that has come about in the attitude of consulting engineers in the matter of ventilation and air conditioning. The increasing appreciation of air conditioning by engineers in charge of large structures is manifested in such up-to-date air conditioning plants as this bank has installed.

* Narowetz Heating & Ventilating Company, Chicago, Ill.

Four Air Conditioning Units Used

The floors above the basements are served from a large fan room in the fourth story, where four air conditioning units are installed. One unit serves the top or sixth floor, which has varying load due to the roof. Another



A Sectional Diagram of the Air Conditioning System Showing How the Air Is Distributed

Several Views of the Interior of the Northern Trust Company's Building, in Which an Air Conditioning System Was Installed to Increase Prestige and Business. The Windows Shown in the View of the Dining Room Are for Architectural Effect Only, Being Illuminated by Electric Lights

unit serves the fifth and third stories that could readily be combined. A third unit serves the fourth story, which has no windows, and a fourth unit serves the first and second stories, or the banking rooms. The supply systems are arranged for recirculation.

A common air intake shaft is carried down from the roof, bringing the air to a fresh air intake chamber in the fourth story and continued down to basement, from which the various units take their respective volumes through air controlled louvre dampers. In each unit, the air is passed through a tempering coil and then through an automatic multipanel oil air filter, from which it is passed through the dehumidifier (which acts as a humidifier in winter) and then through the fan systems to the various outlets. There is a by-pass connection around each dehumidifier so that recirculated air may be reconditioned.

Combined Air Outlets and Lighting Fixtures

All ducts are carried in furred ceilings and the air in the fourth, fifth and sixth stories is introduced through specially designed lighting fixtures or rosettes which permit of a thorough distribution of the air without drafts and allows a very satisfactory direct lighting installation.

Considerable care was given by the architects, Messrs. Frost & Henderson, and the consulting engineers in designing and selecting the rosettes, since they were to be used as air inlets that would not produce drafts and also be satisfactory as lighting fixtures.

A spun circular plate was selected for installation around the duct opening, which was also circular in shape and made so as to direct the air down at an angle, redirecting it by a circular clear glass diffusing plate placed about 4 inches below the ceiling line. The use of glass eliminated all shadows.

The electric light fixture globe is fastened to the bronze framework supporting the glass diffusing plate, resulting in a neat fixture. Each rosette outlet is equipped with a push-fit volume regulating air damper operated through the rosette; neither the damper nor the mechanism is visible.

Air Introduction on Lower Floors Through Wall Grilles

In the first, second and third stories, in general, air is introduced to the rooms by wall grilles about 10 ft. above the floor. In the second story, along the window side of the room, grilles have been installed in the ceiling, with clear glass deflectors for diffusing the air. As these have been worked in with the architectural treatment of the room, they are hardly noticeable.

The recirculated air is returned from points near the floor line back to the fan plants. As is customary practice, all of the toilets throughout the building are ventilated by separate exhaust systems. The kitchen and dining rooms likewise have independent exhaust systems. The basement and sub-basement have independent supply systems with recirculation.

Three separate dining rooms were provided, one for the directors, one for the officers and one for the employes. These dining rooms are located in the fourth story and have no access to the outside air. The windows shown in the illustration of the officers' dining room are for architectural effect only, electric lights being provided behind them to create the impression of sunlight. All offices on the fourth story are also windowless. The architects and engineers of this building believe that in this combination of air conditioning and windowless space they have not only provided ideal atmospheric conditions but also have eliminated much objectionable noise and dust from the city streets.

Refrigeration

The refrigeration machine is of the centrifugal type which combines condenser and cooler in one unit; it is located in the sub-basement and has a capacity of about 225 tons of refrigeration. A direct current motor,

coupled by gearing, drives the centrifugal compressor. The cooled water from this machine is carried up to the various air conditioning units and circulated through the dehumidifiers by a direct-connected motor driven centrifugal pump.

The main pump delivers the cooled water to the four units in the fourth story, which have their tanks connected by equalizer pipes and each dehumidifier has its own centrifugal pump. There is also a dehumidifier plant located in the basement which cares for air conditions there and in the sub-basement. The cooled water for this unit is obtained from a heat exchanger through which all of the cool water from the main pump is passed. This heat exchanger and basement dehumidifier with its pump comprises a separate refrigerated water system.

In order to obtain efficiency in air conditioning, it is necessary to be able to supervise all temperature conditions throughout the whole system. This installation is automatically controlled by thermostats operating valves and dampers and is equipped with a system of indicating devices which enable the supervisor to read at a glance, in his office, all fan discharge, dew point and room temperatures for the purpose of maintaining the desired temperature and humidity, and differentials between the outside and inside air conditions.

The temperatures are indicated on an instrument which measures the electrical resistance through nickel bulbs located in rooms and air ducts, the resistance varying accordingly and in proportion to any change in the temperature of the bulbs. The principle involved is that of a Wheatstone bridge, so that irrespective of the different resistances of the circuits an accurate reading of the resistance of the nickel bulb is obtained and is then indicated on a scale showing degrees Fahrenheit.

As the installation of the air conditioning plant had to be carried out in such a manner as not to interfere in any way with the daily business of the bank, the fourth floor was taken care of in a unique manner during the construction period. The original fourth story had skylights and windows opening on a court, but when the additional stories were added, these means of access to light and air were eliminated. A temporary fan plant with an outside air connection and distributing ducts was installed to take care of this space. This plant and ducts were suspended on steel ropes in the court space below the additional stories and were kept in service until the spaces ventilated could be vacated.

Preheating of Fuel Oil

By Kalman Steiner* and Paul R. Unger*

THERE is much discussion and considerable difference of opinion as to the advantage of preheating fuel oil for commercial use. In power plants and for large industrial furnace work, preheating is quite generally accepted. This article will endeavor to show when fuel oil should be preheated and how it is accomplished. By preheating is meant increasing the temperature of the fuel oil before it enters the burner nozzle and firebox.

Before going further, let us classify fuel oils. According to the Underwriters' Laboratories, fuel oils are divided into six classifications, as shown in the table.

In open hearth steel furnaces, large reverberatory furnaces and large power installations, even heavier fuels than these are used. A typical analysis of oil used in a large installation (as a power plant of 1,000 hp. or similar load) might be as follows:

No. 5 Liquid Asphaltum

Specific gravity	1.05
Flash point	300 F
Sulphur	1.2 per cent
Saybolt Furol Vis. at 122°	200
Water and sediment	0.3 per cent
Pour point	30 F
Btu per gallon	158,000

It will be noted that the Underwriters' classifications and descriptions omit all reference to specific

*Johnson Oil Burner Co., Chicago, Illinois.

Domestic Fuel Oils

Grade of Oil	Flash Point F Min. Max.	Water and Sediment Per Cent	Distillation 10 Per Cent Point	Distillation End Point	Distillation 90 Per Cent Point	Viscosity Max.	Pour Point Max.
No. 1, light domestic oil	110 165	.05	420	600	.....	.....	15
No. 2, medium domestic oil	125 190	.05	440	.....	620	.....	15
No. 3, heavy domestic oil	150 200	.1	460	.....	675	55 seconds at at 100 F, Saybolt Univ.	15

Industrial Fuel Oils

No. 4, light industrial oil	150	1.0	.....	.....	.....	125 seconds at 100 F, Saybolt Univ.	.....
No. 5, medium industrial oil	150	1.0	.....	.....	.....	100 seconds at 122 F, Saybolt Furol.	.....
No. 6, heavy industrial oil	150	2.0	.....	.....	.....	300 seconds at 122 F, Saybolt Furol.	.....

gravity, or the *Baumé* of the oils. It is customary in the trade, however, to assign gravity values to the six grades of oil, as follows:

No. 1	36-40 Baumé
No. 2	32-36 Baumé
No. 3	28-32 Baumé
No. 4	24-28 Baumé
No. 5	18-20 Baumé
No. 6	10-18 Baumé

The low flash points and extreme fluidity of oils No. 1, 2 and 3, eliminate these oils from our consideration of preheating.

Reasons for Preheating

There are three principal reasons for preheating fuel oil. They are:

1. Reduced viscosity gives better atomization and hence higher efficiency of combustion.
2. Reduced viscosity permits of burning heavier and, therefore, cheaper fuels.
3. Reduced viscosity lowers cost of power for pumping and diminishes maintenance cost.

Fig. 1 shows the relationship existing between viscosity and temperature. The curves for oils numbered 1 to 6 are given by the *American Oil Burner Association* and are typical of the six grades in the preceding table. The other curves are by Lieut.-Com. Hyland of the United States Navy. The chart also shows the corresponding values of the three scales used.

In American practice the tendency today is to use the Saybolt Furol for oils with viscosities greater than 25 seconds Saybolt Furol, and the Saybolt Universal for oils with viscosities under 25 seconds Saybolt Furol.

Consider the typical No. 6 oil, with the temperature-viscosity curve shown. At ordinary room temperature, this oil would be so viscous that difficulty would be encountered in pumping it, to say nothing of burning it. But by increasing its temperature to a point between 200 and 250 degrees, it can be made as fluid as a No. 4 oil is at room temperature. This enables an oil-fired plant to use a No. 6 fuel, which of course is much lower in price and higher in heat content than a No. 4 oil.

The characteristics of the No. 5 oil illustrate a typical case of an oil that can be successfully burned cold, that is, at room temperature or even outdoor temperature in winter time. Nevertheless, preheating should be of considerable value in increasing the efficiency of combustion.

The reason for this is twofold; as is generally true of most chemical reactions, heat accelerates the speed of the action and combustion is more rapid, resulting in a hotter fire. Also, the increase in temperature of the oil gives more complete atomization of the liquid. The smaller the particles, the greater the surface exposure of the globules and, therefore, the more effective is the admixture of oil with air. It follows, therefore, that less excess air will be required to complete combustion.

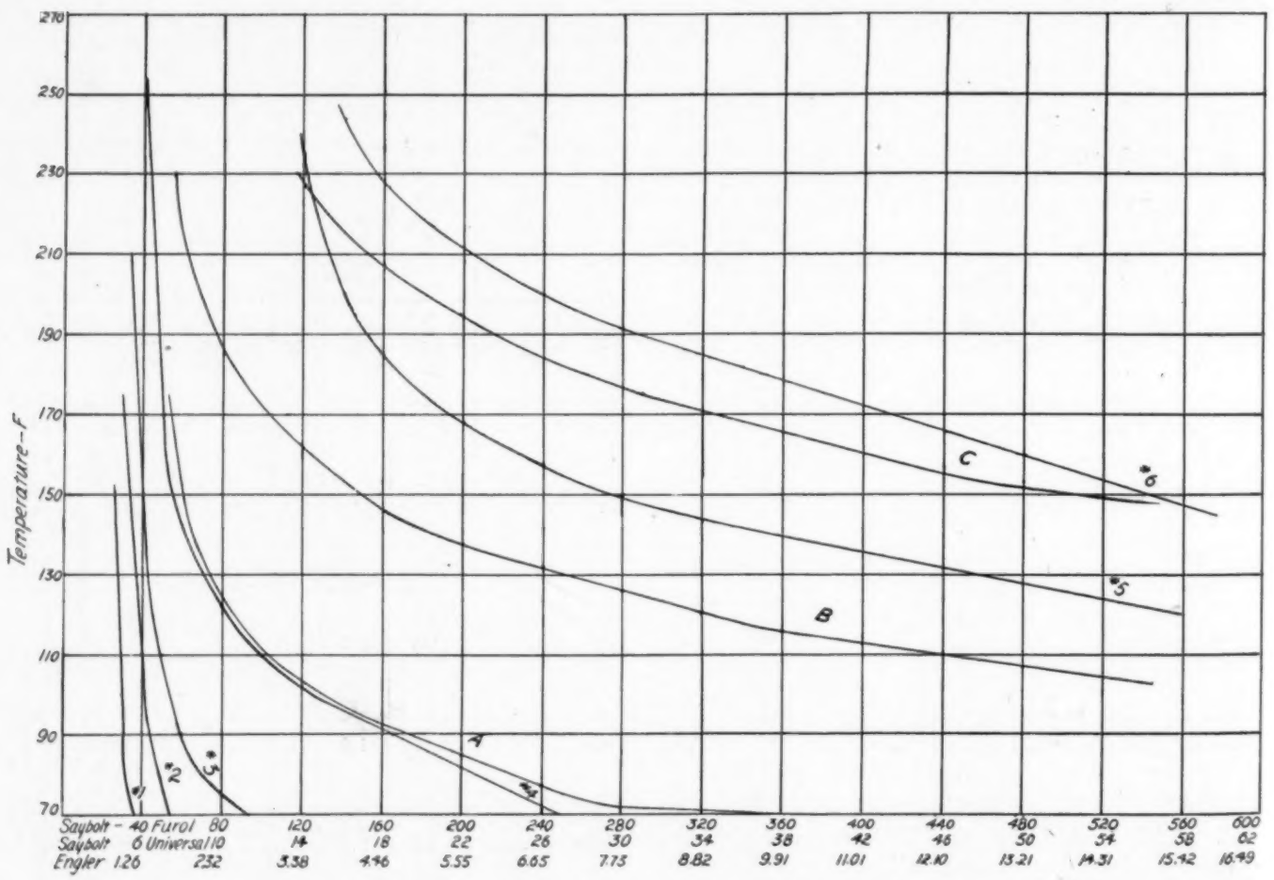


FIG. 1—RELATION BETWEEN VISCOSITY AND TEMPERATURE

Both of the above factors—increasing the flame temperature and reducing the excess air—are reflected in higher CO_2 and higher evaporative efficiency. Another factor affecting combustion efficiency, the discussion of which lies beyond the scope of the present article, is the preheating of the air entering the firebox for combustion.

Fig. 2 indicates the commonly accepted temperatures of preheating for the various grades of oil based on the Baumé gravity. While the classification on a gravity basis is not an especially logical method for judging fuel oils, its use is so widespread in the industries that the authors have shown this curve to assist in a rapid determination of the correct temperature of preheating for an oil of given Baumé gravity. As a matter of fact, if the viscosity of the oil is not too widely divergent from the usual viscosity for the Baumé given, the curve will work out fairly well.

Typical Heaters and Methods of Installation

Steam coils in tanks are used primarily to maintain the heavier fuel oils at the minimum temperature that will assure ready flow of the fluid to the pumps, without regard to the necessary temperature of the oil for atomization. Almost invariably, the oil temperature will again be increased by some type of heater between the pumps and the burners. As oil is drawn from the bottom of a storage tank, it follows that the tank heater capacity need be only enough to heat the lower part of the fuel body in the storage tank, or even only that portion surrounding the suction pipe stub.

Tank coils are, therefore, of two general types—straight lengths laid horizontally at bottom of tank and looped together at ends, and spiral coils looped vertically around the suction pipe. Convection currents are not readily set up in fuel oil, due to the high viscosities, so that the heat transmitted from the coil will not be very effective through a radius greater than 12 inches. This blanketing effect works out very satisfactorily for the purposes of tank heaters, since the heat input to the oil will be concentrated at the point where it is most needed, namely, at the suction stub outlet from the tank.

Estimating Coil Surface

In determining coil sizes required for a given tank, a great degree of accuracy is not required, nor indeed is any great degree of accuracy possible, when calculating heat transfer under these conditions. Heat transfer is largely dependent on the rate of oil flow, as shown in Fig. 10, and in the large body of fuel oil in a tank the rate of flow is low. A transfer rate of 5 Btu per sq. ft. per deg. difference of temperature per hr. is close enough to estimate coil surface.

As a specific example, assume a tank 6 ft. in diameter with a vertical spiral loop around the suction

Fig. 2—Proper Oil Temperature for Fuel Oil

stub, the diameter of the loop being 12 in. It will be necessary to heat the amount of oil withdrawn by the pump. Suppose this to be 600 gal. per hr.

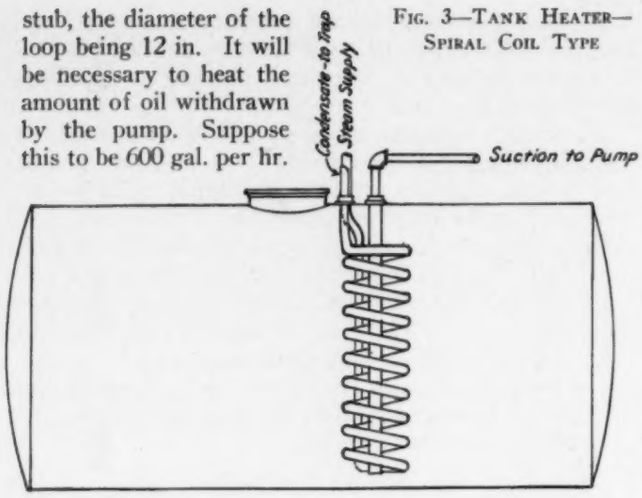


FIG. 3—TANK HEATER—SPIRAL COIL TYPE

The heat required to raise this weight of oil through a 25-deg. temperature rise is 56,250 Btu. With an average temperature difference between steam and oil of 300 degrees, a square foot of coil surface will transmit 1,500 Btu per hour. Therefore, total coil surface of 37 square feet should do the job.

Discharge of Condensate

With coils of this type in underground tanks, provision must be made for discharge of the condensate from the coil. A pipe is brought up from the bottom of the coil through the top of the tank, and discharged into a steam trap. It is imperative that the coil be kept free from the accumulation of water, so that the effectiveness of the coil will not be impaired, and at the same time the steam must not be allowed to escape through the end of the coil. A good steam trap will accomplish the purpose.

Preparing Oil for Combustion

The next step in the heating of fuel oil is intended to prepare the oil for combustion, and as indicated in the previous discussion, the temperature is raised considerably—in the average industrial plant to a point varying from 150 to 200 degrees, depending on the character of the oil.

Methods used for this preheating vary. The heating medium may be steam, hot water, or electricity, or coils and the heating medium passed through a shell containing these pipes or coils, enveloping them completely.

A common type of heater in high pressure steam plants is the U-shaped tube type, illustrated in Fig. 4. It can be operated with either steam or hot water as the heating medium although steam is probably more general. As is true of practically all oil preheaters, this equipment is similar to hot water heating equipment, the principal difference being that with oil, a smaller diameter tube is more effective, and provision must be made to resist the corrosive effect of the sulphur content of the fuel.

A typical method of installation of the U-type heater is shown in Fig. 5. The essential parts of the installation, in addition to the heater itself, are the steam supply, condensate trap and return line, thermostatic steam regulator, and thermometers on inlet and outlet. The method of selecting the correct size heater for a given job is discussed below, under the general theory of heat transmission through heater coils.

Another type of steam heater frequently encountered in larger plants is the multiple pass type, in which the oil flows through a series of tubes surrounded by steam. Compensation for expansion and contraction with temperature changes is accomplished by bowing the tubes, as shown in Fig. 7. In this type, as in all oil preheaters that are assembled with flanged joints intended to give an oil-tight seal, an important consideration is the gasket. The use of proper gasket material may seem to be a trifling detail of installation, but its importance will be appreciated when it is realized that a leaky gasket on a heater can cause shutdowns, to say nothing of the unpleasant mess that can result.

Below-the-Water-Line Heater

In the low pressure heating field, a favorite fuel oil heater is the so-called "below-the-water-line" type. Its construction and installation are practically identical with the construction and installation of the domestic hot water heater. While this type of heater can not be controlled thermostatically by any simple method, as in the case of steam heaters, the below-the-water-line type has to its advantage the facts that it is easily installed and requires practically no attention except cleaning at long intervals.

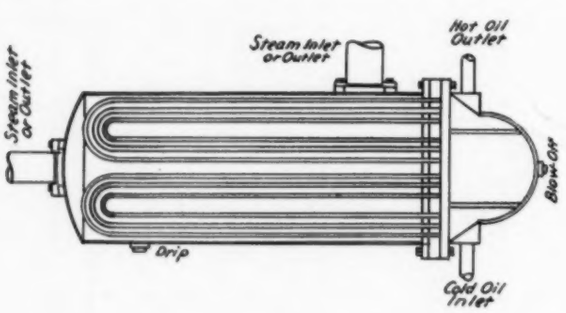


FIG. 4—(LEFT) U-TUBE HEATER

or, more rarely, gas or coke direct firing. The heater or heat exchange medium may be steel or copper pipes, either straight or coiled, or jacketed cylinders. Usually the oil is caused to flow through the pipes

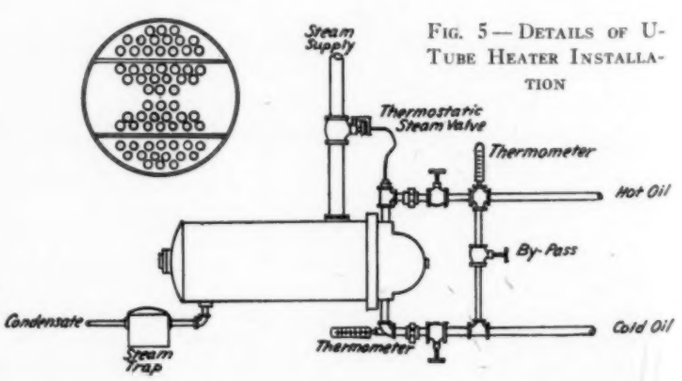


FIG. 5—DETAILS OF U-TUBE HEATER INSTALLATION

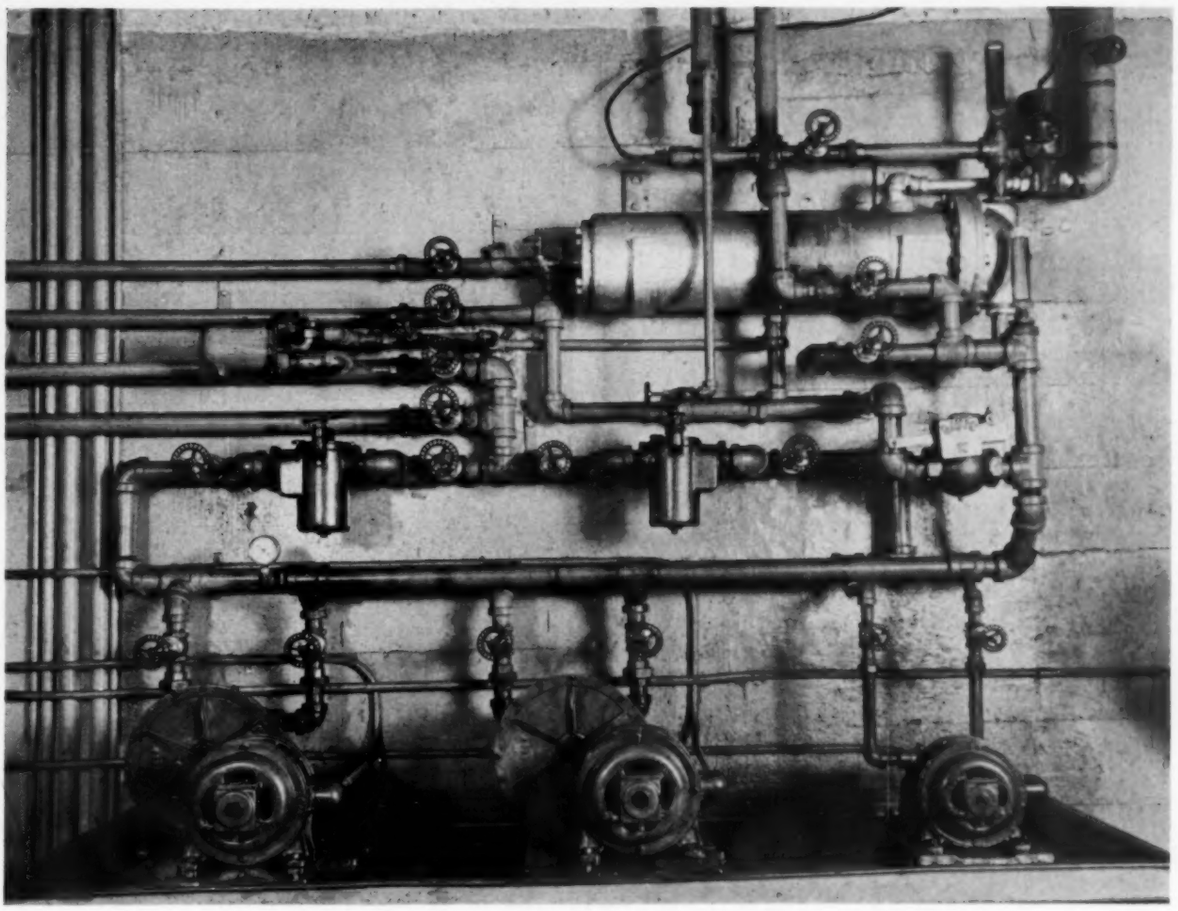


FIG. 6—INSTALLATION OF A U-TUBE TYPE OIL PREHEATER, STEAM OPERATED

A typical installation is that shown in Fig. 8. The two connections from the heater into the boiler are both valved off, so that the heater may be disconnected if necessary without draining the boiler. These valves also serve as regulators, as the rapidity of water circulation, and hence the rate of heat transfer, can be controlled by the valve opening. When this type of heater is used on a multiple boiler job, it can be cross-connected between the boilers, so that the hot water to supply the heater can be drawn from the particular boiler which is being fired at any time.

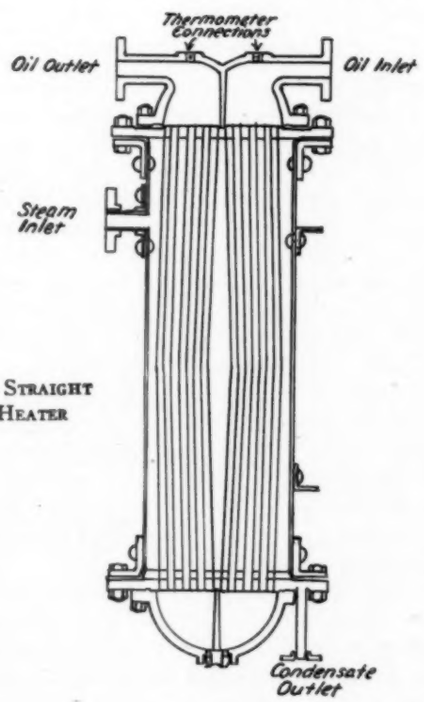


FIG. 7—STRAIGHT PASS HEATER

With the below-the-water-line heater, the water in a boiler will remain hot for a considerable period of time and will cause water to circulate through the heater and thus keep a supply of oil hot for the burner to start up again after a temporary shut down. Where a plant is shut down overnight, for example, the burner will have no difficulty in restarting the next morning.

Electric Heaters

This fact suggests the reason for the third common type, which is the electric heater. The below-the-water-line heater is best adapted to low-pressure work; a high pressure steam job calls for a steam-operated heater, as a general rule. Hence for starting with a cold boiler, an electric heater serves a useful purpose.

Electric heaters consist essentially of a heating element or cartridge, immersed in a container of oil. This type of heater is readily adaptable to thermo-

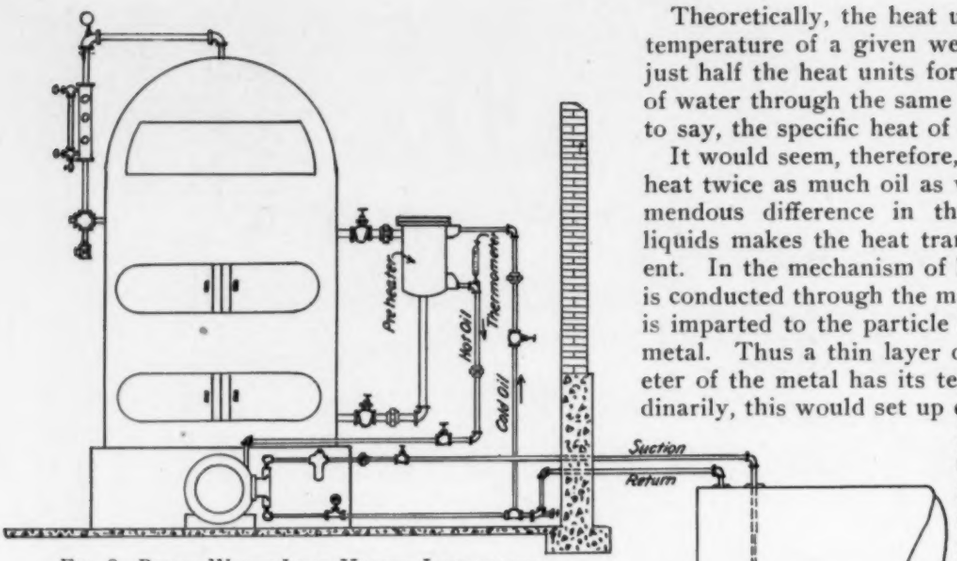


FIG. 8—BELOW-WATER-LINE HEATER INSTALLATION

static control. The details of construction are indicated in Fig. 9.

Theoretical Considerations

Much of the available information on heat transfer in oil preheaters is empirical data based more on the trial and error method than on actual research and test. While some of it has unquestioned authenticity and has stood the test of time, a good deal of it is of

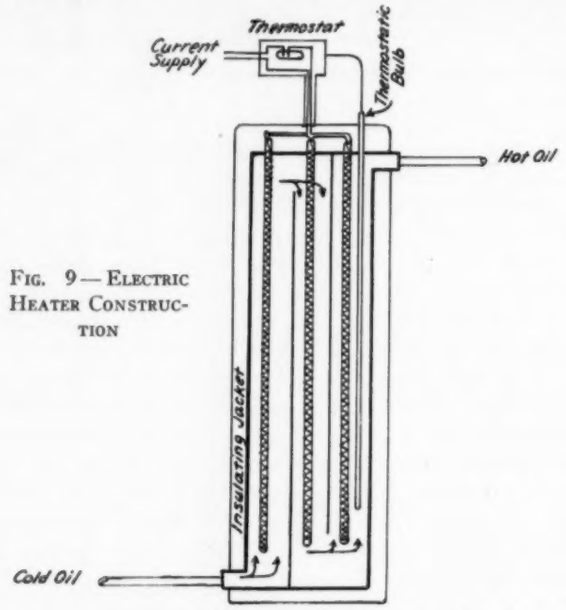


FIG. 9—ELECTRIC HEATER CONSTRUCTION

doubtful value. In general, all estimates for determining surface requirements should be made liberally, allowing an ample factor of safety.

A heat transfer rate diagram is given in Fig. 10. Other sources give an average value of 50 Btu per sq. ft. per deg. difference in temperature per hour for general use in steam-operated heaters. Manufacturers of below-the-water-line heaters use an average value of 12, from hot water to oil. Roughly speaking, the capacity of a heater for heating oil may be said to be one-third the capacity of the heater under the same conditions heating water.

Theoretically, the heat units required to raise the temperature of a given weight of fuel oil should be just half the heat units for heating the same weight of water through the same temperature rise: That is to say, the specific heat of oil is 0.5.

It would seem, therefore, that a given heater could heat twice as much oil as water. However, the tremendous difference in the viscosities of the two liquids makes the heat transfer rate radically different. In the mechanism of heat transfers, a heat unit is conducted through the metal containing the oil and is imparted to the particle of oil in contact with the metal. Thus a thin layer of oil touching the perimeter of the metal has its temperature increased. Ordinarily, this would set up convection currents in the liquid and bring the cold oil again in contact with the metal. But the viscous oil does not set up convection movement; the heated oil moves so slowly that the temperature difference between the oil and heating medium is appreciably reduced. And since it is the temperature difference that creates the potential for causing heat transfer, it is readily seen that the more viscous the oil, the less effective becomes the heat transfer. The transmission rate is reduced.

It follows from these facts that the effect of the heat transfer will vary inversely with the tube diameter. In fact, since the area of a circular cross-section is proportional to the square of the diameter, the rate of heat transfer will be inversely proportional to the square of the diameter. Manufacturers of this type of equipment should, therefore, keep the tube size as small as practicable. It is also obvious that a heater will have a greater capacity with an oil of low viscosity than with a highly viscous oil. Capacities, therefore, should also be stated in terms of oil viscosity.

Temperature Control

Where electric heaters are used, there usually will also be a steam or below-the-water-line heater, unless electricity is very cheap. The oil is first passed through the steam or water-operated heater, and then through the electric heater. Any deficiency under a required temperature will be made up by the electric heater until the main heater is able to pick up and carry the entire load. The electric heater is then automatically cut out by its thermostat and remains out until the oil passing to the burner again falls below a predetermined temperature.

With steam heaters, the control equipment is identical with that used for hot water heating; the thermostatic element is immersed in the hot oil body and the expansion caused by the increase in temperature is transmitted to the operating mechanism of the steam valve, thus controlling the amount of steam admitted to the heater.

As before mentioned, the below-the-water-line heater can not readily be controlled. A thermostat-operated valve similar to that used for steam heaters could be installed in the hot water supply line to the heater but this is not general practice. Inasmuch as

this type of heater is used principally in low pressure heating plants, there is little danger of the oil becoming too hot.

Economics of Preheating

The actual cost of raising the temperature of oil by the three heating mediums discussed can be computed on the basis of the Btu input required and the cost of heat units in the medium used. Thus, to heat 1,000 pounds of oil through a 130-deg. temperature rise will cost from 3 to 5 cents.

It is usually safe to assume that preheating, through increasing efficiency and permitting of burning heavier fuels, will show a net saving of 5 per cent. If, therefore, the 1,000 pounds of oil was purchased at the rate of 3½c per gallon, the actual savings would be, for that amount of oil, 23 cents.

To carry these figures over into actual plant operation, consider a plant developing 1,000 boiler horsepower. Such a plant may average around 3,000 gallons per day consumption, costing $105.00. The effect of preheating would be to save $5.25 per day, at an actual operating cost of $0.77.

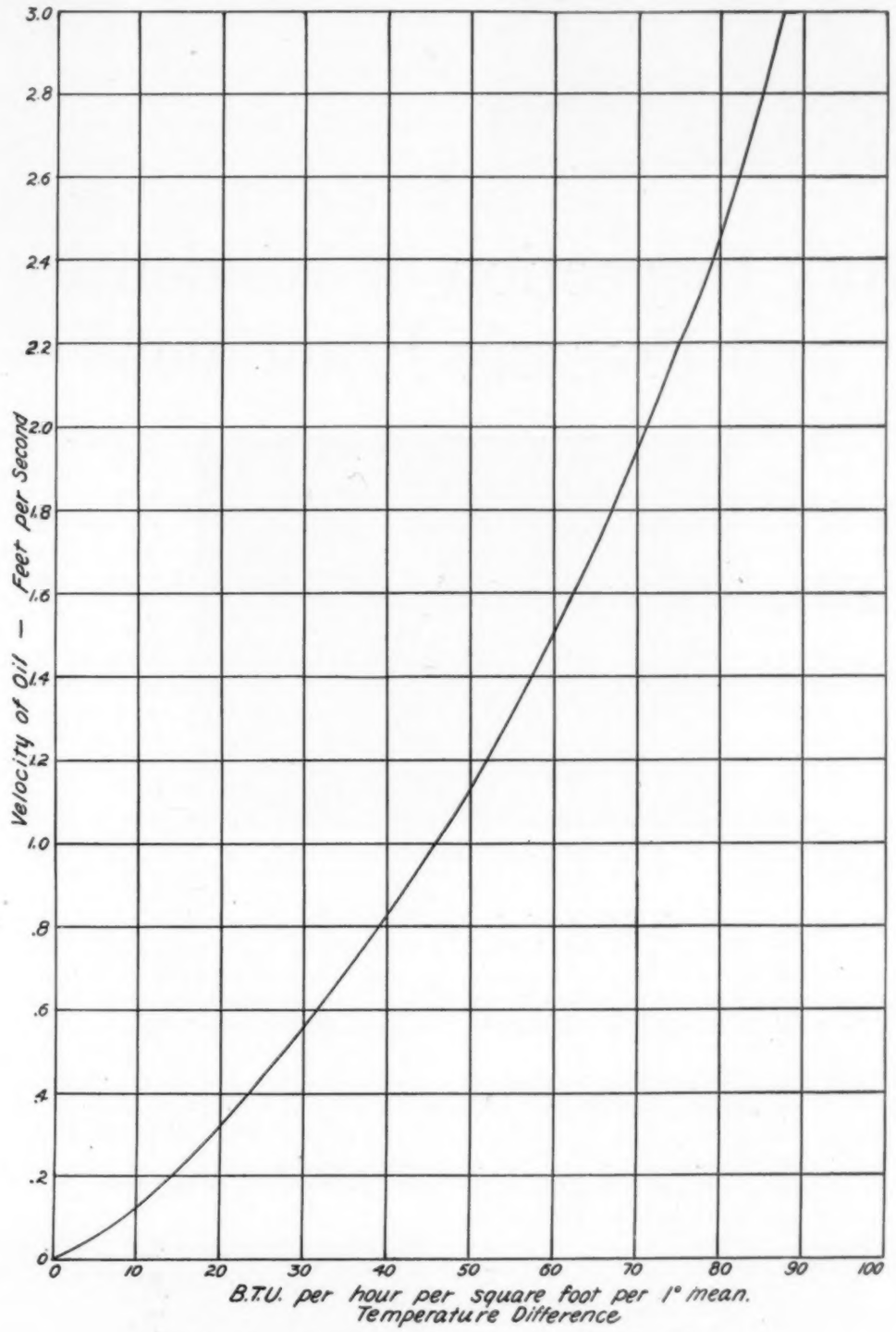


Fig. 10—Heat Transfer Rate Diagram for Fuel Oil Heater

X-RAY INSPECTION FOR ROUTINE EXAMINATION OF WELDED PRESSURE EQUIPMENT

By Herbert R. Isenburger*

X-Ray Inspection of Welded Pipes and Pressure Equipment

IN a former article in HEATING, PIPING AND AIR CONDITIONING, "X-Rays and X-Ray Inspection in Piping," published in June, 1929, the author outlined the physical properties of X-rays and their generation as well as some of the applications of X-rays in the industrial field. The purpose of the present article is to augment the information formerly given and to describe further developments in this rapidly growing field of nondestructive testing.

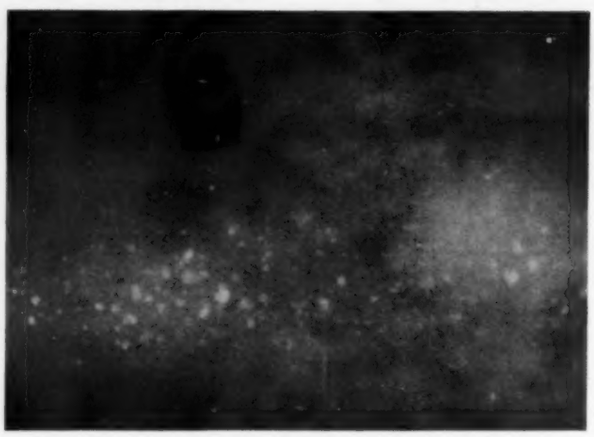


FIG. 1—POROUS WELD—2¼ IN. PLATE

An outstanding feature in this development during the past year is the X-ray installation at the plant of a large boiler and tube manufacturer for routine examination of welded pressure vessels. The equipment and X-ray technique developed for this purpose has recently been described elsewhere.[1]

This installation is shown in the heading illustration. Here, the high tension power plant is mounted on a movable platform and surrounded by a sheet metal housing; the safety drum, containing the X-ray tube, is seen in front of the housing; the tube can be rotated about its axis and raised and lowered if desired. The control cabinet is also attached to the housing. A pressure vessel is set up for production inspection of the longitudinal seams; for the examination of girth welds, the vessel can be rotated about its axis.

Fig. 1 depicts a porous weld under the X-ray, and in Fig. 2 slag and porosity is shown. These two pictures are by no means representative of welded seams in pressure equipment. As a matter of fact, when the proper welding technique has been developed the seams can not be detected in most cases in the X-ray picture. The X-ray inspection in this case is not meant to show defects in the weld, but to prove the soundness of the material. This is the idea which guided the members of the boiler code committee of the *American Society of Mechanical Engineers* when they proposed X-ray inspection in their recent changes of the code.[2]

Another important application of X-ray inspection of welds is the examination of welded seams in pipes and tubings. The radiographic arrangement for the inspection of a circumferential seam of an alloy steel tubing is schematically shown in Fig. 4. On a tubing with 2 inches outside diameter three pictures are made in order to cover the entire weld. Lead markers are placed on the outside with a dot pointing toward the weld. Such a series of pictures is reproduced in Fig. 3. There is

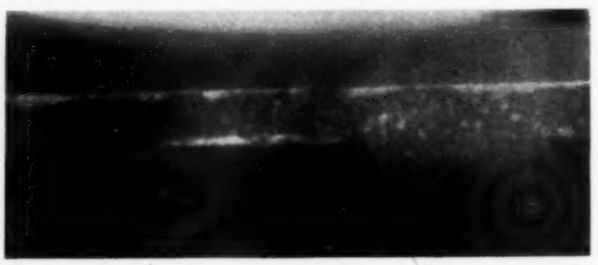


FIG. 2—SLAG AND POROSITY IN A WELD

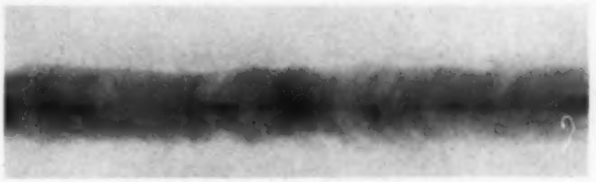
* St. John X-Ray Service Corporation, New York City.

[1] Dr. Ancel St. John, X-Ray Inspection of Fusion Welds in Pressure Vessels; *The Iron Age*. December 18, 1930.

[2] "Proposed Specifications for Fusion Welding of Unfired Pressure Vessels." *Mechanical Engineering*, December, 1930.

FIG. 3—(LEFT) CIRCUMFERENTIAL WELD IN TUBING, SHOWING A CAVITY IN THE .2 REGION

FIG. 5—(RIGHT) A SOUND GAS WELD



a small cavity in the .2 region in the center of the weld; this defect is also observable in the respective places on the two other exposures, but can not be recognized in the print here, since these details were lost in reproduction.

All radiographs shown so far are of welds made by the electric arc. X-ray inspection is equally important for the examination of gas welds. A V-weld of this type is reproduced in Fig. 5. The dark line in the center of the picture is the excess metal over the bottom of the V; the built-up metal on the other surface is also plainly visible. The picture represents a good weld.

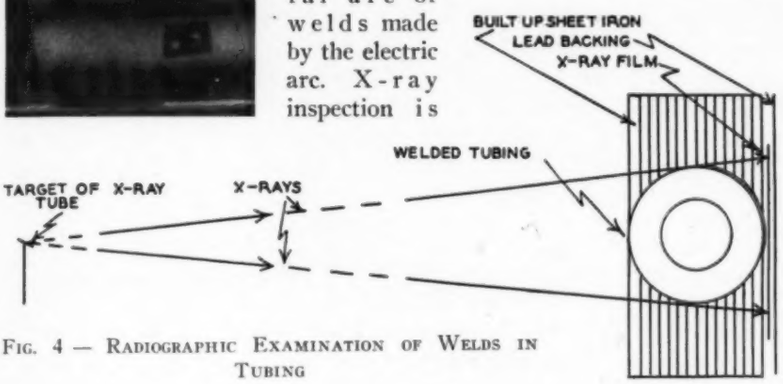


FIG. 4 — RADIOGRAPHIC EXAMINATION OF WELDS IN TUBING

The value of X-ray inspected welds has been appreciated in the industrial field in many ways. First, it is a nondestructive means for proving the soundness of the material and in that way removing the last doubt of the usefulness of the welded material from a customer's mind. Second, to improve and check up on their own production, manufacturers satisfy themselves of the quality of their products. Third, it is useful in educating the welder and checking up on his technique.

With the growing use of welded materials in high-pressure high-temperature services the need for a means to prove the soundness of the structure appeared; X-rays are being used to meet this need.

Fuel Consumption Data for Schools

By John Howatt*

PAPERS that give authentic specific data on costs are extremely valuable, principally because they are so scarce. Most of the articles appearing in journals and magazines deal in theories, generalities or discussions of fundamentals and their application. While theory and practice are extremely important and should properly receive the major attention, costs of operating systems which result from the application of theories and practices should receive careful study for future guidance in designs. In the paper[1] prepared by Samuel R. Lewis, a start has been made in presenting to the public a partial cost report on the operation of a few public school buildings in Toledo, Ohio. The number of schools covered in each group, however, is too small to enable anyone to arrive safely at any definite conclusion and unless conclusions can be made, reports of this nature lose a part of their value.

The writer has had many years' experience in designing and operating heating and ventilating plants of nearly every conceivable type and has records of operating costs extending over a period of ten years for over 300 school buildings, including records of fuel consumption. With the records from this much larger group of buildings it is, of course, safer to draw conclusions from the results than when smaller groups are considered. But even then, it is dangerous because of the varying conditions at different buildings affecting fuel consumption.

Factors Affecting Fuel Used

There are many factors that affect the amount of coal burned per season in a school building besides its size. Comparing one building with another all the variable factors must be brought as near to one constant as possible before comparison can begin. Some of the variables, such as personnel of the teaching force and of the operating force can not be brought to one constant. Those operating school buildings know the different factors that have to be considered and appreciate their great importance.

If we could conclude from our records that this or that type of heating and ventilating plant would always give the most for the money to the board of education, a most valuable service would be rendered. Tabulations of coal consumption of buildings show differences that can be explained only by differences in the vigilance and ability of the operating personnel. Complete and competent supervision will tend to standardize methods but it will not inculcate interest in work where no interest exists and, without interest in the job, mediocrity always will result.

* Chief engineer, Board of Education, City of Chicago.

[1] *Fuel Consumption in Toledo Schools*, by Samuel R. Lewis. HEATING, PIPING AND AIR CONDITIONING, December, 1930, p. 997.

Air Conditioning for Homes —Humidification

"There's no place like home"—unless it be an air conditioned theater, hotel, office building, or other structure. However, there is no reason why our homes cannot be made as comfortable atmospherically as any skyscraper.

Many home-owners are realizing the need of humidification in winter and de-humidification and cooling in summer to keep the home atmosphere always comfortable and healthful. In this article, S. M. Anderson, research engineer, discusses some of the humidifying problems.

By S. M. Anderson*

CHOOSING an air conditioning system for a home has been a puzzling and none too well understood problem to architects, engineers and home owners ever since the widespread application of air conditioning to theaters and public buildings demonstrated its benefits and brought before the public eye the imminent need for similar systems in the home.

The ideal system for the air conditioning of a home is fundamentally one which will keep every occupied room in the house comfortably warmed and properly humidified during the winter time and refreshingly cooled and properly dehumidified during the summer. Usually a system of this sort should likewise remove dust from the air, and certainly will aid in the prevention of its formation. While the latter features are of great importance, sometimes they are not considered in a discussion of air conditioning.

Window Condensation Tests

Personal opinions may govern the degree of warmth or coolness required, but there is a distinct limit within which the amount of moisture that can be allowed in the air of a home must be maintained, depending upon a very definite law of nature.

This law can best be illustrated by reference to Fig. 1, which represents diagrammatically a single and a double glass window separating the inside warm air of a house from the outside air, at a temperature of 0 F. No reference is made to wind velocities of the outside air past the window surface because the experimental data were determined for average conditions involving a number of different days. Whereas the wind effect does have some bearing on the temperatures indicated, the normal differences in velocity from day to day do not vary the temperatures sufficiently to alter the conclusions which will be drawn from this discussion, and the wind effect is therefore disregarded.

The temperature inside the window in each case is purposely chosen at 72 F, representing the temperature to be desired, though not necessarily the temperature of greatest comfort unless a relative humidity of 50 per cent is maintained within the room. It is obvious from a study of the diagram that the temperature of the glass window, and more particularly that of the inside surface of the window, must be at some intermediate temperature between 72 F and 0 F, depending chiefly upon the over-all rate of heat transmission through the glass. When this intermediate temperature coincides with the saturation temperature of the moisture within the room,

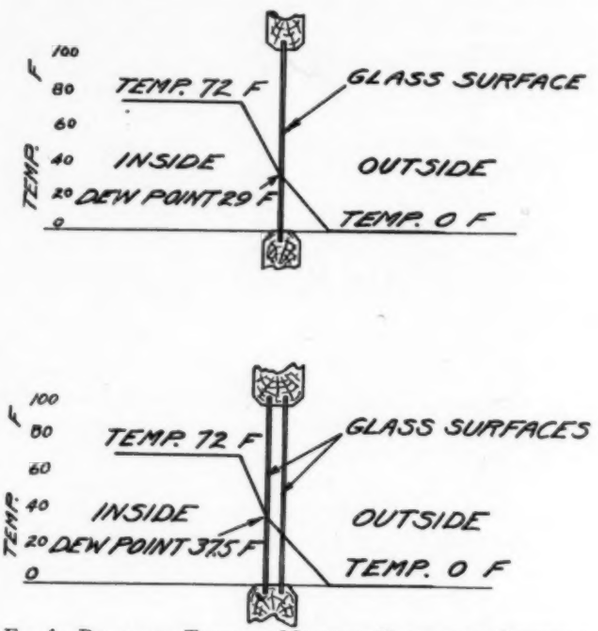


FIG. 1—RESULT OF TESTS ON MOISTURE DEPOSIT ON ORDINARY GLASS WINDOWS. ABOVE—A SINGLE GLASS WINDOW WITH 20 PER CENT RELATIVE HUMIDITY INSIDE. BELOW—A DOUBLE GLASS WINDOW WITH 28 PER CENT RELATIVE HUMIDITY INSIDE

a condition of equilibrium is established which would be unbalanced by any further addition of moisture, causing such additional moisture to be deposited from the inside air upon the inside window surface.

This equilibrium temperature is known as the dew point because of its frequent occurrence in nature in the formation of dews on the grass, leaves and other chilled surfaces. Fortunately, in most building construction, the window glass is the coldest inside surface of wide occurrence, and if the moisture content of the rooms of any home is kept within the limits of the dew point of the windows, there will be no deposit of mois-

* Research Engineer, Air Conditioning Department, B. F. Sturtevant Company, Boston, Mass.

ture elsewhere about the house. The dew point temperature, therefore, is a determining factor in establishing the maximum amount of humidity that can safely be added to household air, and a disregard of the phenomenon of moisture deposit at the dew point temperature may lead to trouble through over-humidification.

Tests (see Fig. 1)indicate that when the temperature out-of-doors is 0 F and the temperature of the room in 72 F, the first trace of moisture occurs on single glass windows at 29 F dew point, and on double glass windows at 37½ F dew point within the room. It is interesting to note that the deposit on the single glass window would be in the form of frost because the dew point in this instance is below the freezing point of water. Under such conditions, therefore, to obtain an inside temperature of 72 F without getting more than a trace of moisture on the windows, the maximum relative humidity that would be permissible would be 20 per cent for single glass and 28 per cent for double glass windows.

Owing to these low relative humidities, the room would feel under-heated, and it would be necessary to heat it to approximately 78 F to give the optimum comfort temperature. This additional heat would have the effect of producing an even lower relative humidity with the same dew point.

Without some method of humidity control, therefore, in those portions of the country where the temperature is likely to fall to 0 F or lower, it would be unsatisfactory to install a system that would produce a relative humidity higher than 20 per cent for single glass and 28 per cent for double glass windows; yet it should not be necessary to penalize the humidity system of a home for the entire winter by requiring this low humidity each day of the season in order to prevent excessive condensation during the occasional extremely cold weather.

Only on days when the outside temperature is between 35 F and 45 F (depending upon the exposure of the windows and on whether they are of double or single glass) is it possible to obtain a temperature of 72 F inside a house and a relative humidity of 50 per cent without the slightest trace of condensate forming on the window panes. An analysis of the experimental results illustrated in Fig. 2 will demonstrate this. It should be borne in mind that authorities are now well agreed that 72 F and 50 per cent relative humidity represent comfortable and healthful winter time conditions and are conditions of air temperature and moisture content to be desired in winter on as many days as possible. The nearer any apparatus can bring the air of a home to this temperature and relative humidity, the more ideally is the system designed.

Maintaining the Proper Indoor Conditions

Consider for a moment, quantitatively, what it would mean to attain the desired air condition of 72 F and 50 per cent relative humidity in an average sized home. For purposes of comparison, assume a house having a cubical content of about sixty thousand cubic feet, and a radiation heat loss through the walls of seventeen hundred Btu per hour per degree mean temperature difference between inside and outside air temperatures. This represents a fairly close approximation of the relationship between the cubical content and radiation losses of a well insulated house.

Assume a dew point temperature of the outside air equivalent to 10 F. This may be a dry bulb temperature of 10 F and 100 per cent relative humidity, or 20 F dry bulb temperature and 60 per cent relative humidity, which is a more usual condition for severe winter weather. The temperature to which the house must then be heated to give an optimum comfort condition for winter time without the use of any sort of humidifier would be 81 F dry bulb temperature (from a comfort chart).

Owing to the fact that the air within the house comes

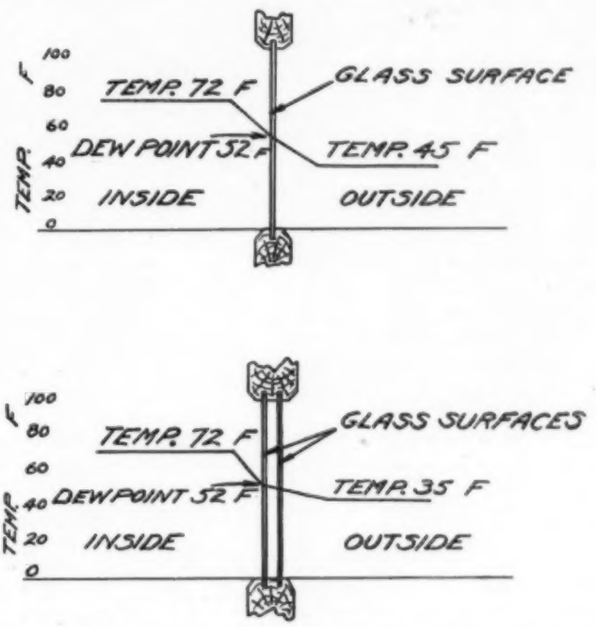


Fig. 2—Result of Tests on Moisture Deposit on Ordinary Glass Windows. Above—A Single Glass Window With 50 Per Cent Relative Humidity Inside. Below—A Double Glass Window With 50 Per Cent Relative Humidity Inside

from the outside (it is customary to allow a complete air change every hour due to natural leakage) the air of the house would also be at a dew point temperature of 10 F, and the relative humidity under these conditions would be only 6 per cent. However, due to the fact that there is a very pronounced tendency for moisture to evaporate into the air from plants, food, furniture and persons living in the house, the dew point would probably be raised to about 20 F instead of being maintained strictly at the dew point of the outside air, as estimated above. Under these conditions, it would be necessary to heat the house to 80 F dry bulb temperature to give the same degree of optimum comfort, and the relative humidity would then be only 10 per cent. Obviously enough, this is far from the ideal condition of 72 F dry bulb temperature and 50 per cent relative humidity, yet it represents exactly the same degree of comfort.

Amount of Heat Necessary

The amount of heat necessary to maintain these temperatures can be determined by a simple calculation.

Outside temperature	20 F
Inside temperature	80 F
Specific heat of air	.2375

Air density at 20 F	.0828 lb. per cu. ft.
Heat lost by radiation	1,700×(80°—20°)=102,000 Btus per hr.
Heat lost by air leakage (assuming one air change per hour)	60,000×.0828 ×(80°—20°) ×.2375 = 70,800 Btus per hr.
Total heat required	172,800 Btus per hr.

The amount of water evaporated from a humidifying system to give the above conditions would, by hypothesis, be 0 gallons per hour, inasmuch as the moisture absorbed from natural sources about the house is not considered in this discussion.

The Same House with 50 Per Cent R. H. and 72 F

Now consider the same house outfitted with an ample humidifying system and heated to the same optimum comfort temperature, but to 50 per cent relative humidity and only 72 F dry bulb temperature.

Outside temperature	20 F
Inside temperature	72 F
Air density at 20 F	.0828 lb. per cu. ft.
Total heat per pound of air (to humidify from 20 F and 60 per cent relative humidity to 72 F and 50 per cent relative humidity)	19.7 Btus per lb. (taken from psychrometric chart)
Heat lost by radiation	1,700×(72°—20°)=88,500 Btus per hr.
Heat lost by air leakage	60,000×.0828×19.7=97,900 Btus per hr.
Total heat required	186,400 Btus per hr.

At this point it should be noted that in this case actually more heat is required to give the lower temperature of 72 F and 50 per cent relative humidity than to give the higher temperature of 80 F with only 10 per cent relative humidity. This may in part be due to the original assumption of a full change of air by natural leakage in the house every hour. Some authorities may consider this assumption too generous for a well built house. If the air leakage is accordingly reduced by 50 per cent, the comparisons would be altered by a proportionate decrease in heat losses, and the following results would obtain:

Outside temperature	20 F
Inside temperature	80 F
Heat lost by radiation	102,000 Btus per hr.
Heat lost by air leakage	35,400 Btus per hr.
Total heat required	137,400 Btus per hr.

Outside temperature	20 F
Inside temperature	72 F
Heat lost by radiation	88,500 Btus per hr.
Heat lost by air leakage	48,950 Btus per hr.
Total heat required	137,450 Btus per hr.

Based upon the above figures, the amounts of total heat required are practically identical.

Amount of Water Evaporated

If an analysis is made of the actual water evaporated to produce the ideal temperature of 72 F and 50 per cent relative humidity, even more surprising results are evident.

Amount of moisture in air at 20 F	.000181 lb. per cu. ft.
Amount of moisture in air at 72 F and 50 per cent relative humidity	.000630 lb. per cu. ft.
Pounds of moisture required to attain 72 F and 50 per cent relative humidity (assuming one air change per hour)	60,000×(.000630-.000181)= 26.9 lb. per hr.
Gallons of moisture required to attain 72 F and 50 per cent relative humidity (assuming one air change per hour) (1 gal. of water = 8.33 lb.)	26.9 ÷ 8.33 = 3.23 gal. per hr.

If a figure of one-half an air change an hour is considered correct, there would be required just one-half of this amount, or 1.62 gal. per hr. of moisture, over and above that which would be supplied by plants, furniture, food, etc., within the house.

With an outside temperature of 35 F and 55 per cent relative humidity, such as might be represented by the double glass window shown in Fig. 2, there would

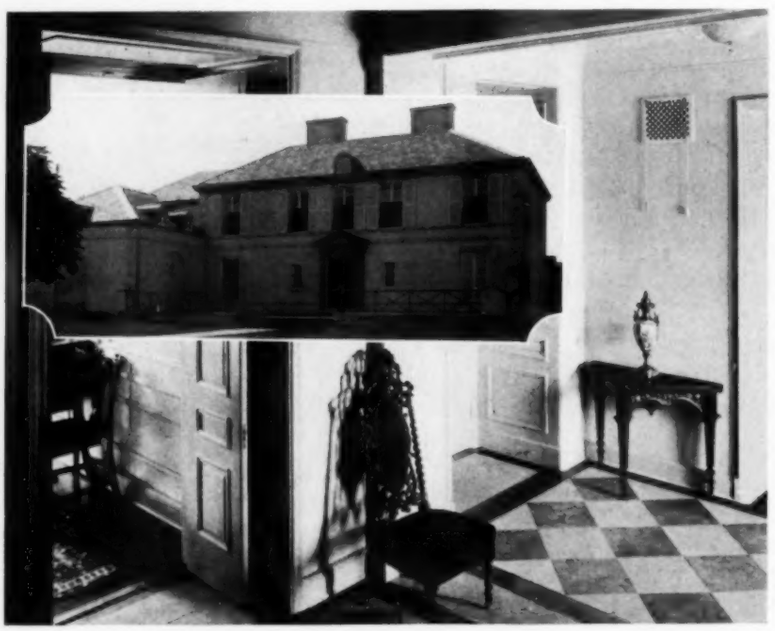


FIG. 3—INTERIOR OF A RESIDENCE, SHOWING THE SUPPLY AND RETURN GRILLES. THE INSET IS AN EXTERIOR VIEW OF THIS HOME

have to be an evaporation of 2.35 gal. per hr. to give 72 F and 50 per cent relative humidity inside, assuming a full air change every hour, and 1.18 gal. per hr. evaporation on the basis of half an air change hourly.

Throughout this analysis, no attempt is made to allow for moisture condensed from the air on the glass window surfaces in cases where the temperature of the glass is below the dew point temperature of the room. Moisture condensed in this manner is, in effect, simply transferred from the humidifier to the window surface and consequently must be considered as useless moisture evaporated by the humidifying system.

The Necessity of Some Method of Control

Supplying the proper humidification that will not give trouble during the coldest days of winter (condensation may discolor woodwork, streak wall-paper, etc.) is a problem that must be met by some sort of control, preferably automatic. The following example may serve to illustrate the need of maintaining a balance between the output of the humidification system and the condition of the incoming air:

In a residence in Baltimore there has been installed a humidifying apparatus intended to supply water vapor to the air of the entire house by means of a fan system and connecting supply and return duct work. Water is recirculated through four nozzles in this system, and only a portion of the air of the house passes through the humidifying chamber. The entire volume of air in the house passes through the fan system in about six minutes, this large volumetric displacement being necessary as the apparatus is intended for summer cooling as well as for winter heating.

The owner, desiring to humidify his home before the control system was completely installed, switched on the apparatus one cold day last winter and awaited results. Within fifteen minutes every window in the house had become coated with moisture and even the mirrors on the walls showed signs of condensation. Needless to say, the humidifying nozzles were immediately shut down until after the installation of the humidity control system.

The humidity control apparatus used in this Baltimore home involves the use of the photo-electric cell, a device which has attracted considerable interest in engineering circles lately, as it has many applications. Because of the interest in the photo-electric cell, perhaps it would be well to describe its function in controlling the humidity in the home mentioned above.

How the Control Works

This control functions only as a deposit of moisture is made on a transparent medium—such as either a single or double glass window. (A diagram is shown in Fig. 4.) It consists fundamentally of a source of light and a lens creating a beam of light which shines through the window and is reflected by a mirror upon a photo-electric cell which is sensitive to the intensity of the light falling upon it. This photo-electric cell is the same element that is used in certain processes of recording talking moving pictures, and consists essentially of a sort of radio detector tube which is sensitive to changes of light intensity rather than to oscillations of radio frequency.

When the window glass is clear, the full intensity of the light from the light source passes through the glass and falls upon the photo-electric cell, causing it to operate, through an amplifying tube and a control relay, the particular type of humidifying apparatus to which it may be connected. Thus, as moisture is continually added to the air of the house as the air is passed through the humidifier, the dew point is raised thereby until it reaches such a temperature that moisture begins to condense on the window. As soon as the condensate begins to form on that portion of the window through which the light is shining on its reflected course to the photo-electric cell, a portion of the light is diffused beyond the field of action of the cell by the drops of water collected on the glass. This causes a reduction in the intensity of the light falling upon the cell, which in turn causes the control relay to open, shutting down the humidity supply apparatus until the window pane is again clear.

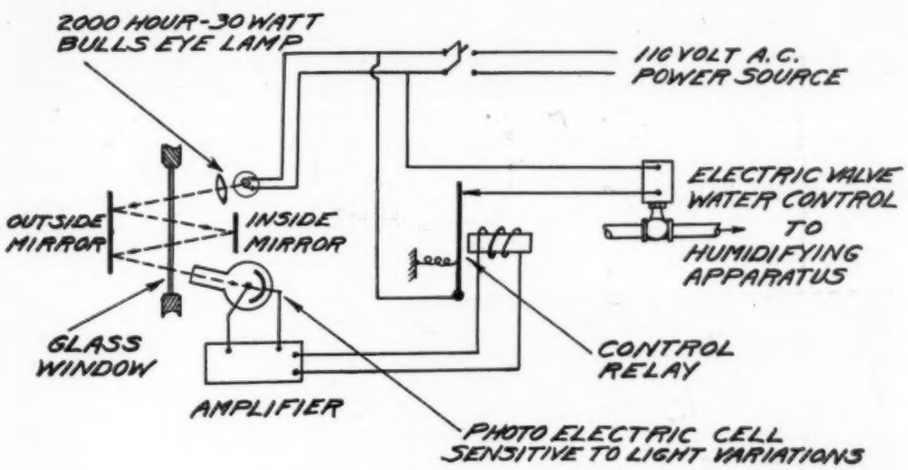


Fig. 4—A Diagram of the Photo-Electric Humidity Control Installed in a Baltimore Home

This window will, of course, remain fogged for perhaps an hour until the average dew point of the air in the room, and particularly that of the air which is circulating near the window, has fallen low enough to prevent further condensation upon the glass and to evaporate what moisture is already there. Conversely, when the window is again clear, the apparatus supplying the humidity is automatically caused to resume operation. Therefore, the control always provides the maximum relative humidity allowable for each day of the winter—which, as has been pointed out, will be approximately 50 per cent during the major part of the time.

Modern Heating and Air Conditioning Practices Applied to a Bank

By Samuel R. Lewis*

THERE are a few unconventional procedures in the large mechanical plant of the Ohio Bank Building at Toledo which it may be interesting to record.

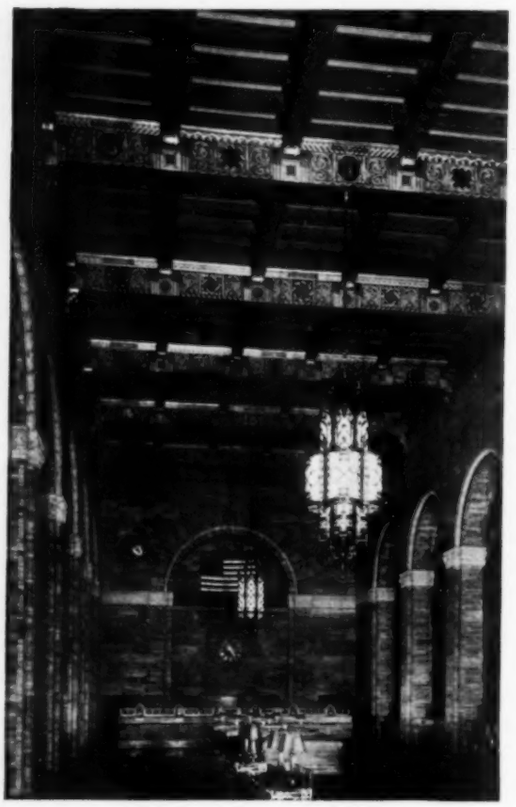
One exceedingly unusual feature is that the architects, Mills, Rhines, Bellman & Nordhoff (of Toledo), while carrying an assuredly competent staff of mechanical engineers for their own exclusive service, often employ an outside engineer on the larger and more important projects in the hope that by so doing they may receive suggestions and criticisms induced by the broader horizon of the consultant. The writer cooperated in this manner on the Ohio Bank building. This cooperation was entirely at the initiative of the architects, and is a refreshing alternative from the routine situation in which the independent engineer so often is rather forced upon the architect.

Here's a description of a heating and air conditioning system in a bank; its several rather unusual features will suggest helpful ideas to other consulting engineers and contractors.

The boilers are supported on the building structural steel rather than on the masonry surrounding the stokers. The contractor on the job devised an interesting method involving a pneumatic receiver arrangement for boiler protection in case of pump failure. These and other points are covered.

Boilers Suspended from Structural Steel

The boilers serve the new building, and also furnish steam for heating the old Ohio building, now called the Board of Trade building, with supply and return mains extended through a private tunnel across the street. The boilers are interesting especially because they are suspended from the structural steel of the building itself, and are among the first boilers of the low pressure firebox type to be so suspended above the stoker retorts rather than to be supported on the masonry surrounding the stokers. It is fair to say, in this connection, that independent supports for stoker-fired low pressure boilers are coming rapidly into vogue.



THE MAIN BANKING ROOM. THE AIR INLETS TO THE PUBLIC SPACE ARE SLOTS IN THE SIDES OF THE TRANSVERSE BEAMS AND ARE ALMOST INVISIBLE ABOVE THE OCTAGONAL MEDALLIONS

Underfeed Stokers Are Used

The boilers have unit type electrically-operated forced draft underfeed stokers, which receive the bituminous screenings which are used for fuel by gravity from overhead bunkers, which in turn are fed from coal trucks in the alley, without any of the manual or mechanical labor ordinarily required for coal handling. Ashes are removed in cans on a special elevator. Air for combustion comes from the exhaust fan in the adjacent engine and machinery room, being proportioned consistently for that purpose. The plant is well equipped with combustion controlling, indicating and recording instruments.

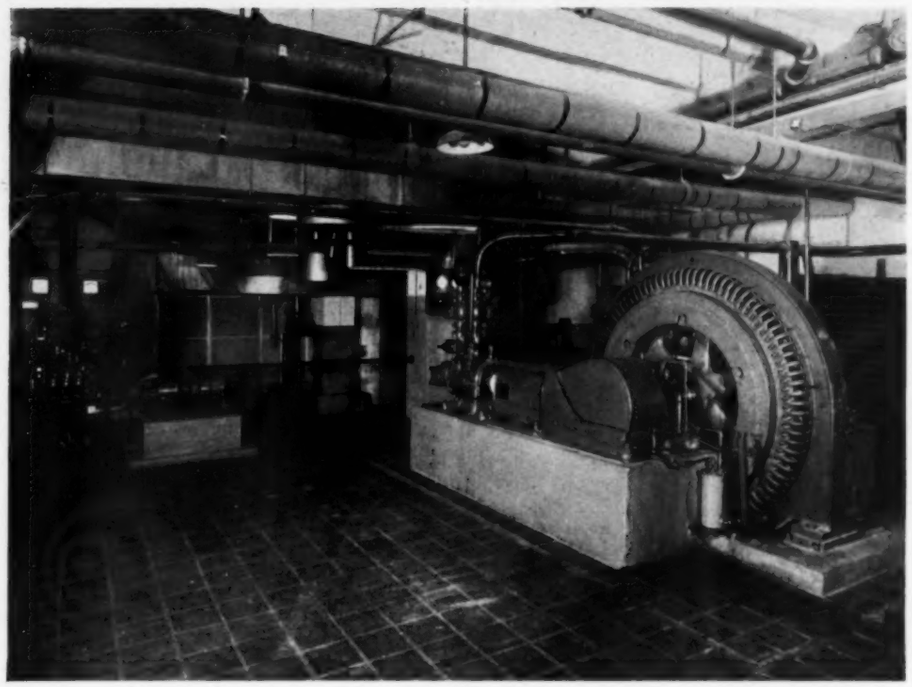
Automatic Governor Controls Centrifugal Feed Pumps

The boilers, operating at 15 pounds or less steam pressure, are fed by an electric centrifugal pump which always maintains a head of at least twenty pounds against an air cushion in a large pressure tank, from which the water enters each boiler in a steady and closely-controlled stream as governed by an automatic water-line governor on each boiler. The various vacuum pumps discharge into an atmospheric receiver, which feeds the boiler feed pump.

Contractor Devises Boiler Protection Scheme

Should the water level in the atmospheric tank drop sufficiently from any cause so as to open a balanced float valve, city water, which is always at about fifty pounds pressure, will enter the tank, providing water for the boiler feed pump, and if the pump

* Consulting engineer, Chicago.

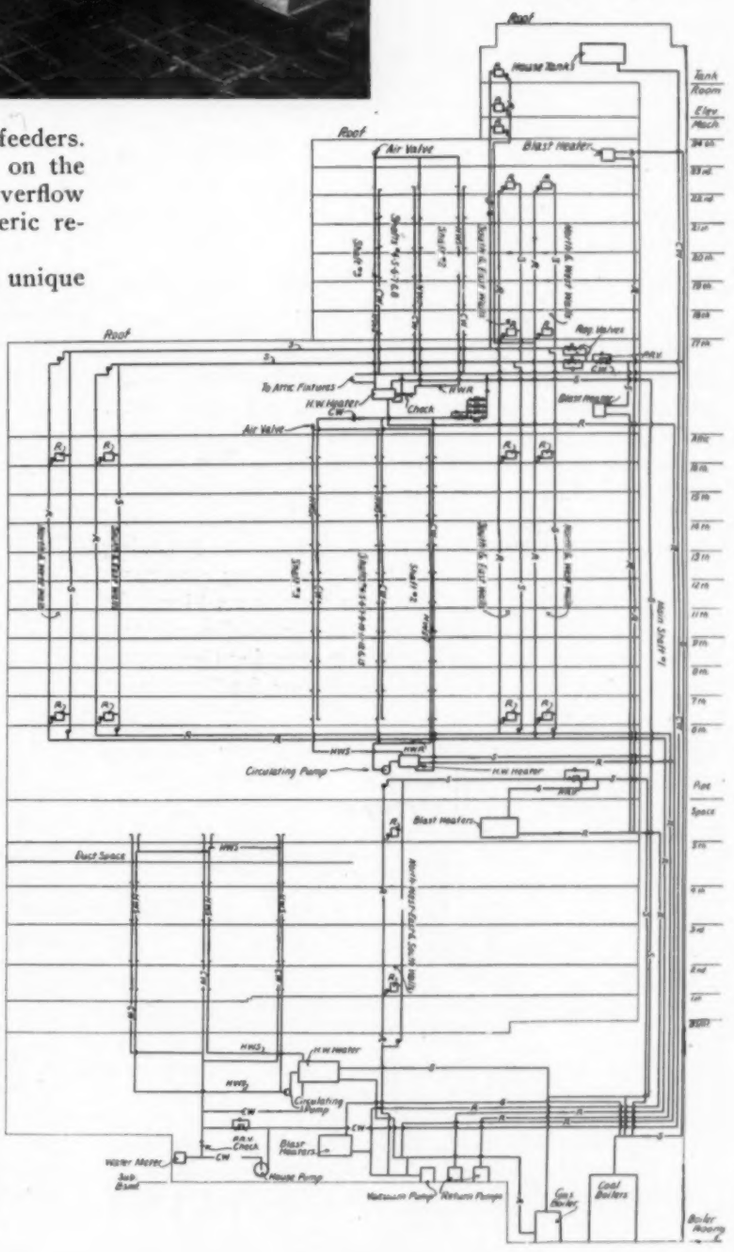


In the Refrigerating Plant Used for Air Conditioning, There Is a Carbon Dioxide Compressor Driven by a Direct-Connected Electric Motor

fails will be fed directly by the automatic feeders. There is, of course, a relief or safety valve on the pneumatic tank and the usual vent and overflow arrangements are provided for the atmospheric receiver.

This pneumatic receiver arrangement is an unique scheme for boiler protection in case of pump failure, and was devised by Howard C. Baker, the contractor who installed the whole plant. All oil-burning and all gas-burning boilers, and all stoker-fired boilers, should have automatic water feeders and low water cut-outs which will stop the fire in case of low water. When dependence is made on pumps for boiler feed, the automatic water feeders for city water especially are desirable. It is much safer to keep these devices limbered up and in perfect adjustment if they operate constantly, rather than if they operate only in the rare emergency when a pump failure occurs. The procedure of introducing *all* boiler feed water through the automatic feeders, therefore, possesses decided advantages over the more common practice of using the automatic feeders for emergencies only.

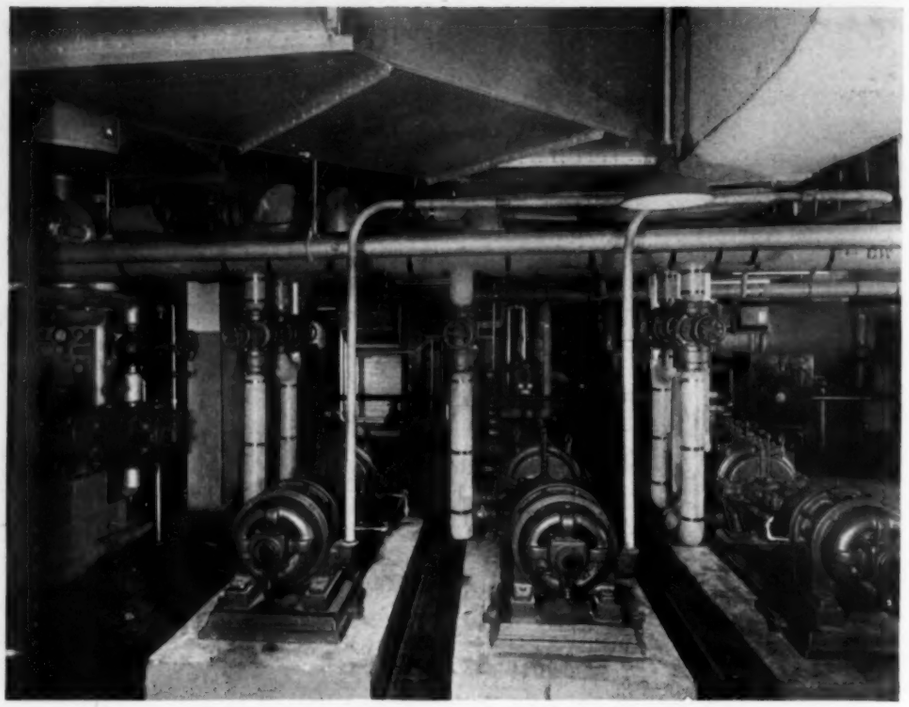
Below — A Schematic Diagram of the Piping. The Heating of the Upper Stories Is Zoned for North and West Exposures Relatively to South and East Exposures. The Hot Service Water Circulates in Three Zones



New Building Has Zoned Vacuum System

The new building is provided with a high-vacuum return system for the direct radiation, arranged in zones according to the orientation with different vacuum pumps and pressure regulators for each zone.

The old Board of Trade building has an air-line vacuum system, that is, the radiators are fed by a single-pipe down-feed system from a separate reducing valve with thermostatic air valves on each radiator, all connected up with very small sized air piping. These air-removing mains terminated originally at a steam jet-driven ejector. In making the new



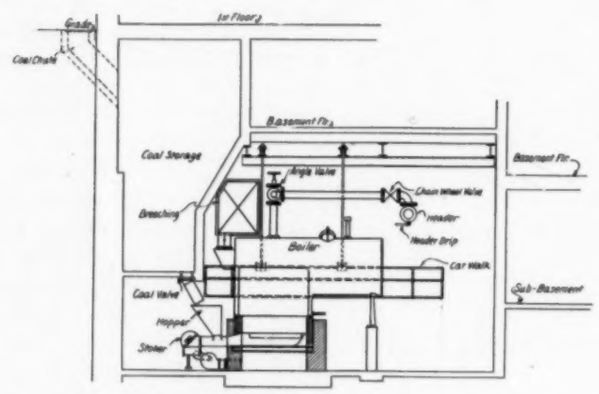
A View of Some of the Pumps. An Insulated Supply Duct Carrying Conditioned Air May Be Seen at the Right, Overhead, While at the Left Is an Exhaust Duct

connections for service to the old building from the new boilers, the air lines were connected to the suction of a new electric vacuum pump, while the ends of the old down-feed vertical supply mains were each provided with a float trap, the outlet from which communicated with the suction piping of the vacuum pump.

It is, of course, necessary to carry several pounds pressure above the atmosphere on the direct radiation of the old system in order to balance this with the direct radiation of the new system, which may operate at as much as twenty-four inches of mercury lower than atmospheric pressure.

Various Operating Pressures Explain Need of the Boiler Feed System

The indirect heating and ventilating apparatuses for many departments of the new building, being under automatic temperature control and using much air directly from out-of-doors, likewise operate at pressures which will show on the pressure side of the gage, while the boilers normally carry about ten pounds steam pressure, feeding each zone or grand division of the system through a separate reducing valve. These widely different operating pressures suggest that the several vacuum pumps could not be expected to feed the boilers directly in the conventional manner, and disclose the reason for the atmospheric receiver and the separate boiler feed pump.



Section Through Boiler Room. The Boilers Are Suspended from the Structural Steel of the Building. They Have Gravity Feed of Coal from Hoppers in the Alley

Temperature Indicator

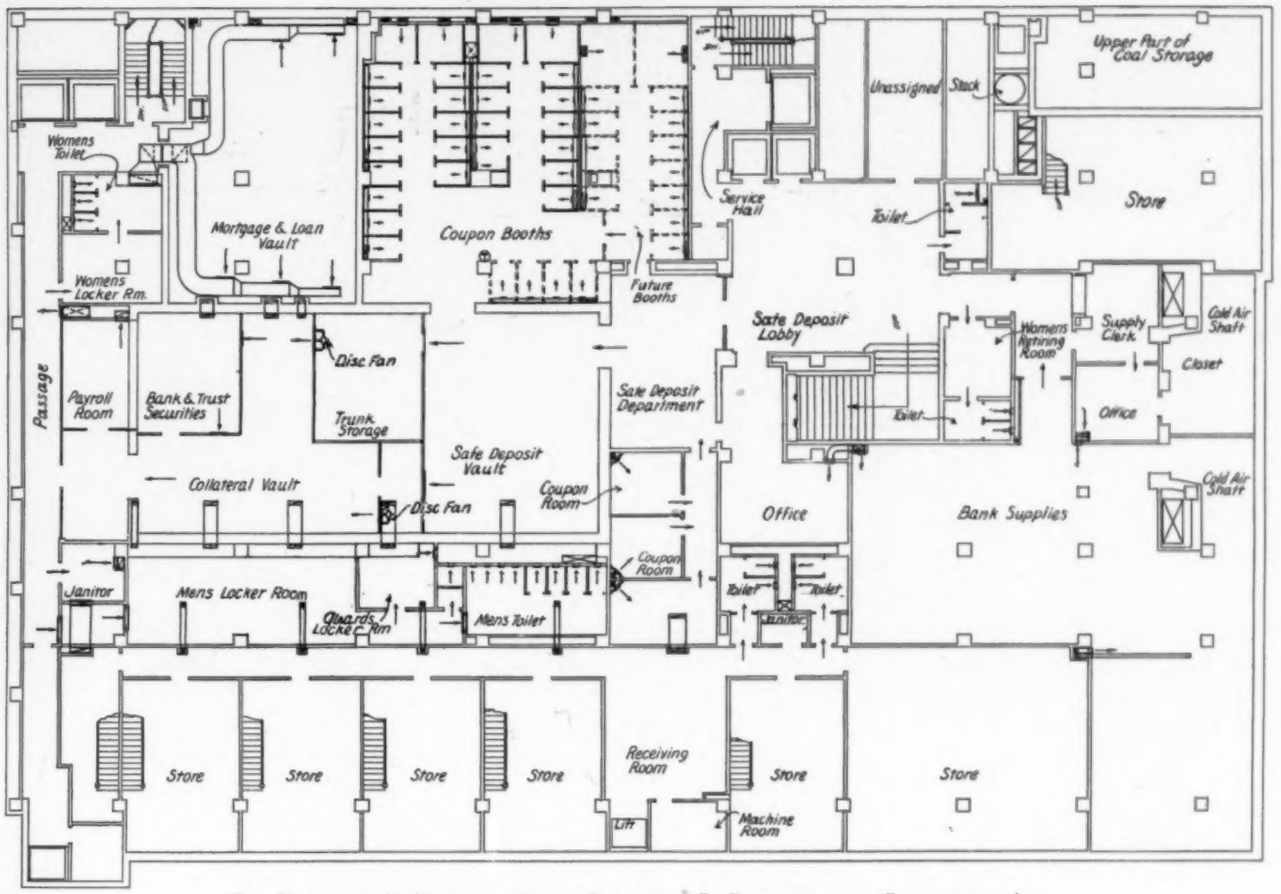
There is provided in the engine room, an electrically operated temperature-indicating instrument which shows the temperature at any one of seventeen stations in representative departments of the building and in the various parts of each air conditioning apparatus.

Conditioned Air for Deposit Vaults Below Street Level

The safety deposit vaults are placed in the lowest public space, which is one story below street level. Under the entire safety deposit area, except under the space occupied by the vaults themselves, there is a clean-cut duct and pipe space about ten feet high. The general returns from the direct radiator heating system are accessible here. The supply and exhaust air ducts for the coupon rooms and other safety deposit auxiliaries are in this shallow basement-like room.

The coupon rooms each receive a positive supply of conditioned air, and these rooms exhaust to the local corridor, which in turn discharges the cool, little-used air through and diagonally across the safety deposit vault, entering through one door and departing through the other door, with a supply auxiliary cool air into the vault through removable duct-sections in the main entrance to the vault. This removable duct-section feeds an air supply to distributing ducts built above and as a part of the safety deposit boxes themselves.

The exhaust air from the vault eventually is removed through the main toilet and locker rooms for the bank employes, located in the basement. Thus the deep-down safety deposit department always receives one hundred per cent air from out-of-doors; all of this air first cooling the coupon rooms; then



THE BASEMENT IS ENTIRELY BELOW GRADE AND IS PROVIDED WITH CONDITIONED AIR

passing with a perceptible movement through the coupon room corridors into the vault, then again in an appreciable fresh, invigorating breeze passing through the otherwise stuffy corridors used by the employes, to aerate thoroughly the locker and toilet rooms on its way to the final outlet via the toilet exhaust system; the inlets to which are placed near the sanitary fixtures in each room.

This method of sweeping large volumes of air from one room through another, has been tried thoroughly and is one expression of modern air conditioning practice. Adequate automatically-controlled bypasses are provided to preserve continuity of the air circuit around the vault instead of through it at times when the doors of the vault are closed. What little heating is required for these subterranean departments is cared for by the entering air, but this air, winter and summer, usually needs to be somewhat cooler than the air normally in the rooms. The register-inlets of the air supply for the coupon rooms, fresh from the air conditioning plant, are just under the counters, and are under control of the customer, who may close them during the comparatively short duration of each occupancy, if he desires.

A feature of this entire air circuit is that the coupon rooms are cool and fresh at all times, as are the toilet and locker rooms, without any cost-prejudice which would follow conventional separate ventilation methods, necessitating local ventilation of unoccupied rooms and spaces.

Machinery Room Cool and Pleasant

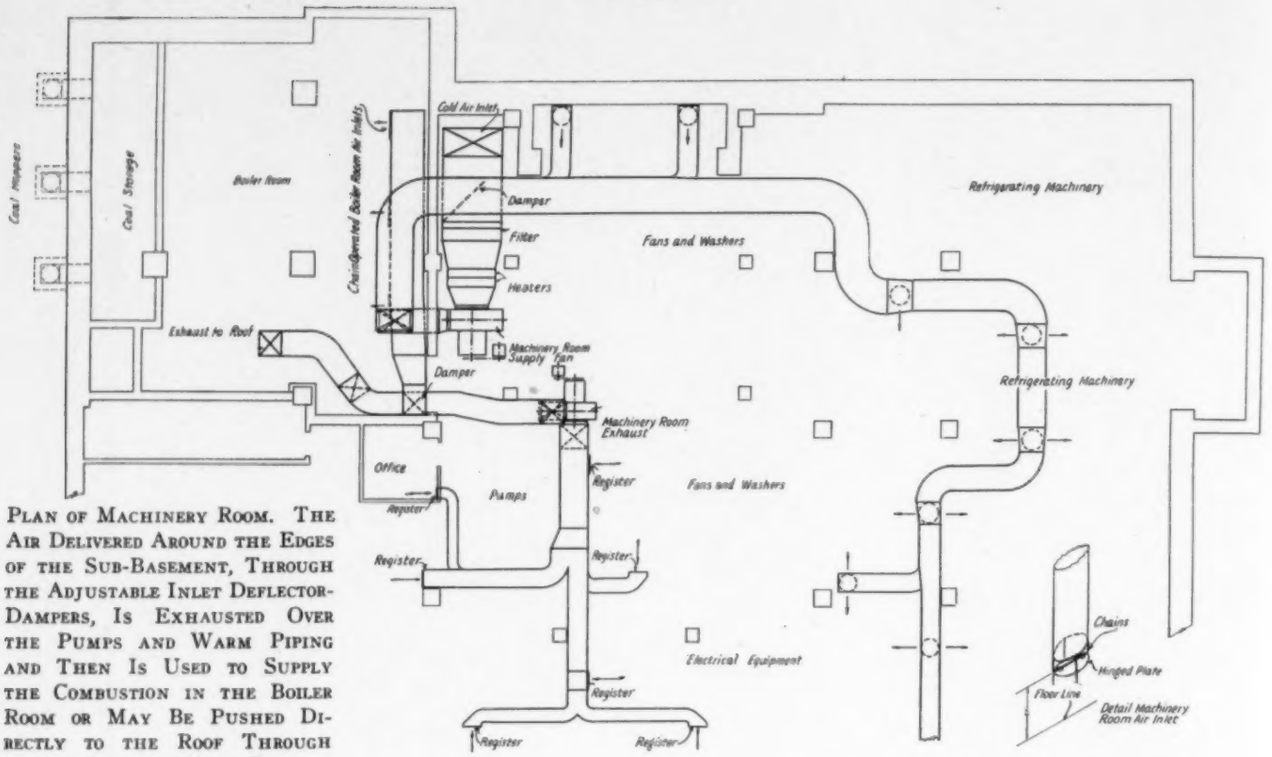
The machinery room has its own separate supply and exhaust systems, with overhead horizontally-looking diffusers for air delivery, and with the exhaust fan discharging to the boiler room so as to furnish an ample supply of air for combustion, with an alternative out-board exhaust. The machinery room proves to be exceptionally cool and pleasant.

Supplying Air to Banking Spaces

The savings bank on the first story receives air from a separate system and exhausts to separate ducts which permit of recirculation or of out-board exhaust. For this department air circulation is horizontal and downward from furred-in ceiling ducts, with the horizontally-looking adjustable diffusers in the centers of each bay. These special diffusers are a feature of the entire air conditioning system. The few windows are all protected by direct radiators.

There are two heavily used main entrances on the first story; both are provided with electric recirculating fans and indirect heaters of large capacity. Recirculating unit heating machines prove quite satisfactory for vestibules in general.

The main banking room is on the second story and continues through to a ceiling midway between the fourth and the fifth stories. On each side of this capacious room are departmental and work rooms on the second, third, and fourth story levels, and all of these rooms receive properly conditioned air from



PLAN OF MACHINERY ROOM. THE AIR DELIVERED AROUND THE EDGES OF THE SUB-BASEMENT, THROUGH THE ADJUSTABLE INLET DEFLECTOR-DAMPERS, IS EXHAUSTED OVER THE PUMPS AND WARM PIPING AND THEN IS USED TO SUPPLY THE COMBUSTION IN THE BOILER ROOM OR MAY BE PUSHED DIRECTLY TO THE ROOF THROUGH THE OUTBOARD VENT RISER

the two main supply apparatuses in the fifth story pipe space.

The main banking room, more than forty feet high, receives its supply of air from horizontally-looking grilles in the sides of the nine transverse girders, with auxiliary ceiling-diffusers in the galleries at the third story level. The exhaust air leaves the main banking room at the floor, to several ducts along the side walls, and this air is, to a considerable extent, recirculated by the main supply fans; though a full sized out-board exhaust shaft is provided through the building to an outlet in the roof.

The auxiliary rooms in this zone have direct radiation and ceiling diffusers, with outlets along the inner walls at the floor.

Prevent Cool Down-Drafts at Windows

There are enormous windows at the north end of the main banking room, with the very noticeable down drafts of cool air which always attend such areas. To overcome this draft, special recirculating fans with indirect heaters are provided in the pockets available above the entrance doors of the first story, directly under these windows.

Warm air is delivered by these fans at rather high velocity upward against this glass surface, and the scheme proves to be far more effective than conventional direct radiators without fans.

The Fifth Floor

On the fifth story there are provided club facilities for bank employes, including a large dining room, served by a kitchen. There is an exhaust fan for this kitchen, with a separate shaft running clear through to the roof. This fan, abetted by the toilet exhaust fans, normally provides for removal of enough air from the banking room circuit which, of course, must be replaced by air from outside, to answer all requirements for renewal purposes.

The two main air supply systems are located on the fifth story, between the main trusses, and there are provided longitudinal pipe and duct spaces below these trusses and above the bank ceiling. The transverse trusses of the main banking room are very heavy, but are designed so as to allow the central north and south corridor to pass through them, thus utilizing to excellent advantage all of the spaces between the trusses for first class office purposes.

The upper stories of the building have enclosed direct radiators and are without mechanically delivered air supply.

All toilet rooms, however, have mechanical exhaust ventilation with controlled metal risers leading to an exhaust fan in the tower.

Preventing Chimney Effect of Building

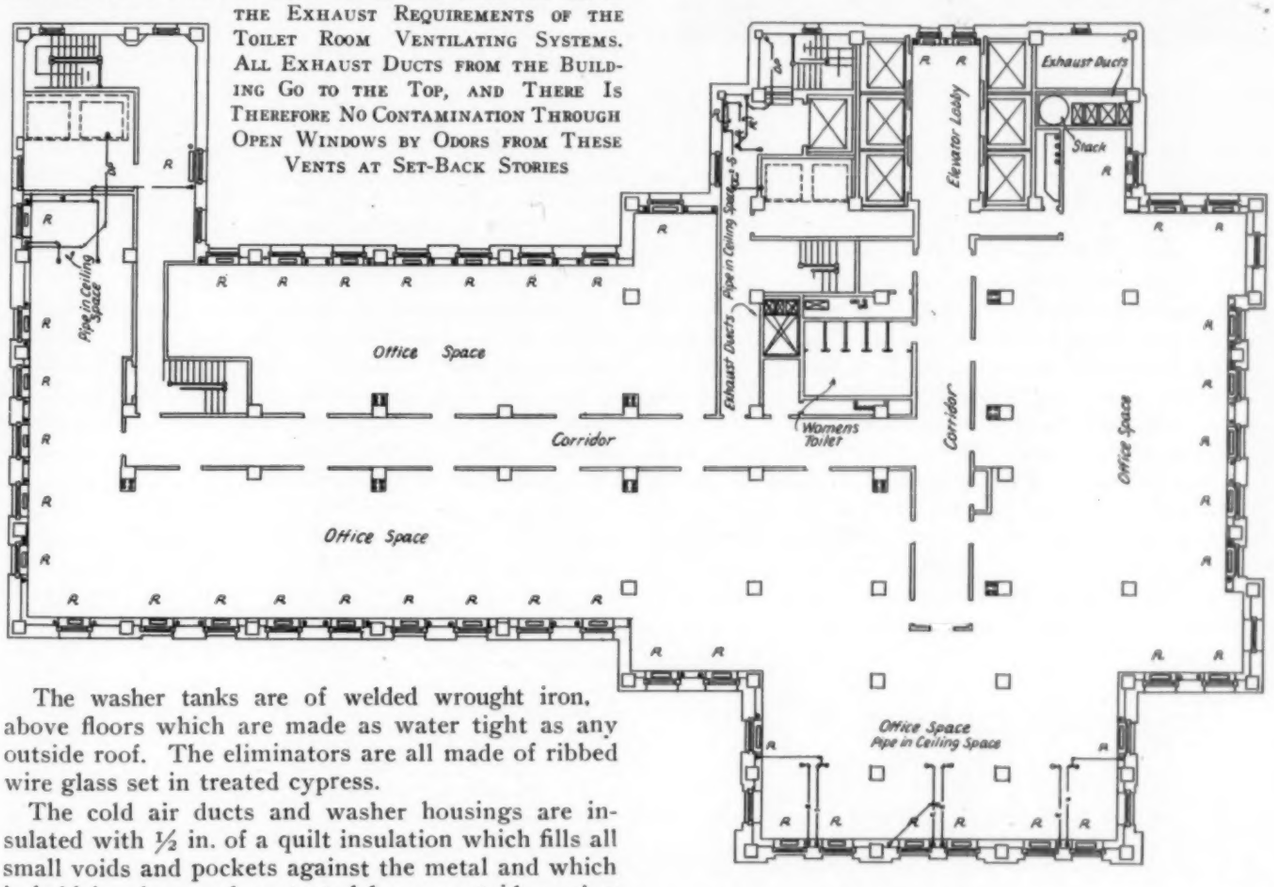
In all heated lofty buildings, we have experienced difficulty from in-going drafts in the lower stories and from out-going drafts in the upper stories, due to the chimney-effect of the building. An attempt was made to overcome this trouble in the Ohio Bank building. Supply fans with air filters and heaters were installed at the tops of each of the two main stair shafts and were arranged to deliver clean tempered air under pressure into these shafts, which have doors at all stories. The results from this scheme are highly satisfactory, as the shafts are comfortable, and there is a noticeable reduction in the heavy suction which usually is manifest at the stair-doors of skyscrapers.

Four Sets of Air Conditioning Equipment

There are four air cooling and drying apparatuses, two on the fifth story for the main banking room and

its auxiliaries and two in the basement, one for the safety deposit department and one for the savings department. These each consist of a series of sprays and built-in cooling coils using direct expansion carbon dioxide supplied from an electric-driven compressor in the basement. Each washer has its own local recirculation pump. Each washer has a standard bypass provided with a controlled tempering heater, and a controlled outside air intake, all being so arranged as to cause delivery of air at optimum temperature obtained by a suitable admixture of recirculating and outside air, further adapted by a mixture of the air from the washer with that by-passed around the washer, all under automatic control.

THIS PLAN OF THE SEVENTH STORY IS TYPICAL OF THE REMAINING SIXTEEN STORIES. TWO SUPPLY FAN SYSTEMS MAINTAIN A PRESSURE OF AIR ON THE STAIR HALLS AND THIS AIR SERVES THE EXHAUST REQUIREMENTS OF THE TOILET ROOM VENTILATING SYSTEMS. ALL EXHAUST DUCTS FROM THE BUILDING GO TO THE TOP, AND THERE IS THEREFORE NO CONTAMINATION THROUGH OPEN WINDOWS BY ODORS FROM THESE VENTS AT SET-BACK STORIES



The washer tanks are of welded wrought iron, above floors which are made as water tight as any outside roof. The eliminators are all made of ribbed wire glass set in treated cypress.

The cold air ducts and washer housings are insulated with ½ in. of a quilt insulation which fills all small voids and pockets against the metal and which is held in place and protected by an outside casing of ½ in. board insulation, the corners and joints of which are sealed with elastic cement and covered with metal tees and angles.

There are seven supply fans, each with air filters; ten exhaust fans and five recirculating or booster fans.

There is one 190-ton carbon dioxide compressor using a double pipe condenser, water for which is obtained from an artesian well on the property.

Size of an Air Cooling Plant

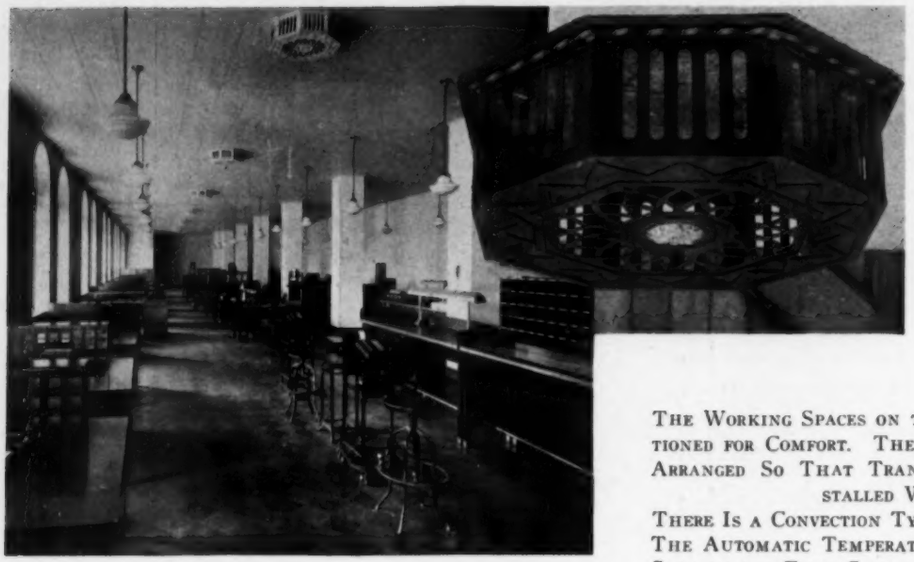
Refrigerating machines when used for drying and cooling air do not have to pre-cool the water, as when they are used for making ice, and can be operated on comparatively small pressure-differences between their suction and discharge sides. It becomes necessary, then, for each machine to have two ratings, one for air conditioning and one for ice making, and they may be 100 per cent apart.

The heat removal required in an air cooling and drying installation is that for reducing relative humidity, plus the heat removal required to offset warm walls and warm glass and warm air leakage through these materials; plus the heat removal required to offset the heat gain from electric lights, electric motors, etc.; plus the heat removal from the bodies of the people.

The Ohio building refrigerating plant makes no ice in any twenty-four hours, yet ordinarily we can not visualize this plant until we multiply the basic heat removal required per hour by 24 (hours) and divide the product by 142 (heat in Btus to melt a pound of ice) and then divide the quotient by 2,000 (pounds in a ton) and so learn that our demand is 270 tons of air cooling and drying capacity or about 169 tons of ice-making capacity. It seems reasonable to hope for an eventual trade custom which will rate these machines in Btu per hour.

Piping Is Gas Welded

A very extensive use was made of gas welding throughout the construction of the plant, on all heating and plumbing piping. During the progress of construction it was illuminating to observe the facility with which the workmen cut and welded all



THE WORKING SPACES ON THE FOURTH STORY ARE ALL CONDITIONED FOR COMFORT. THE INLETS AND OUTLETS FOR AIR ARE ARRANGED SO THAT TRANSVERSE PARTITIONS MAY BE INSTALLED WHEREVER DESIRED

THERE IS A CONVECTION TYPE RADIATOR UNDER EACH WINDOW. THE AUTOMATIC TEMPERATURE CONTROL THERMOSTAT MAY BE SEEN ON THE FIRST COLUMN. THE INSERT SHOWS THE CEILING INLET AND OUTLET

special blacksmith work such as trap stands, pipe anchors and supports for tanks.

Expansion of vertical pipes throughout the piping system is taken care of by loops or bends which are furred into the walls.

The Heating and Hot Water Systems

The steam supply system is well subdivided and is provided with valves to facilitate zone control in winter with economical hot water service in summer.

The basement and first to fifth stories inclusive have blast heating and auxiliary direct radiation under automatic temperature control.

The sixth to twenty-second stories including service stories in the tower have high-vacuum steam heating with separate zone control of the direct radiators on the north and west and on the south and east from supply mains in the attic above the sixteenth story with returns in the pipe space above the fifth story.

Hot service water is provided by steam heated transfer-heaters, one for all requirements below the sixth story by an apparatus in the basement; one for the sixth to the sixteenth stories by an apparatus in the fifth story pipe space, and one for the sixteenth story to the top of the building, by an apparatus in the attic above the sixteenth story. The two lower zones of these hot water circuits have each an electric circulating pump. The hot water heaters receive steam from a separate system of piping which is served by a gas-fired steam boiler in summer and which circulates at that time by gravity.

Cold water is fed to the separate-pressure heating zones above described for the hot water circuits, through separate pressure reducing valves with house pumps on a by-pass around a main-line reducing valve arranged to take advantage of the city water pressure. This pressure normally is available to serve the lower zone of the building.

The plant is remarkable in the fact that service complaints have been very few, both in summer cooling and in winter heating. Credit for at least part of this is due to the efficient operation of the plant by its staff.

Re-Routing Ducts Without Charts

By Henry G. Schaefer

IT IS unquestionably a difficult and tedious task, though one not without its recompense, for the engineer to design properly a system of duct work for a given purpose. In the development of the design, not the least of the duties of the engineer is the consideration of the space requirements of the system and the coordination of the ducts with the piping of the plumbing, heating and sprinkler equipment, as well as with electric trunk conduit and structural work.

We all appreciate, however, that installations that are made exactly as planned, and in which no deviations from the original conception occur, are woefully in the minority. How often is the engineer summoned to a conference on the job or at the architect's office to reroute and re-proportion a duct so that some afterthought in the matter of arrangement may be cared for, or that a special requirement of a particular tenant may be met? All too often, we will all agree.

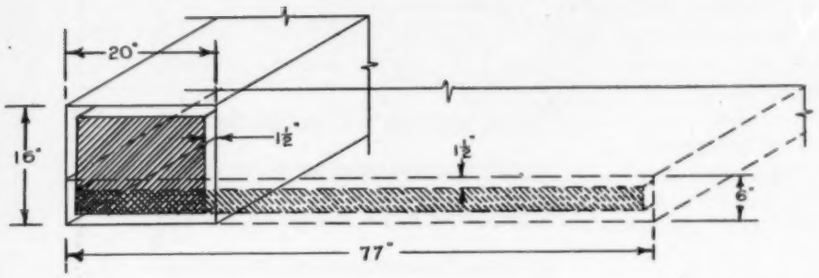
A conscientious engineer will refuse to name definite sizes at such a conference, for he knows that a reproportioning of duct sizes on the basis of equivalent areas is just an open invitation to trouble. His refusal is variously construed as ignorance or indifference, and is certain to react to his disadvantage.

Rule-of-Thumb for Changing Duct Sizes

A good rule-of-thumb for use in such emergencies, and one which will produce almost accurate results—at least results that will be accurate enough for all practical purposes—has long been used with consistent success by the writer. This rule is based on the theory that a lubricating layer of air, adjacent to the duct surface, about 1½-in. in thickness, cuts down the effective cross-sectional area of the sheet metal duct three inches in each dimension.

A Specific Case

Let us assume a specific case: a 16 in. x 20 in. must be re-routed through a ceiling in which only a 6-in. depth



A 16-IN. BY 20-IN. DUCT RE-ROUTED THROUGH A CEILING WITH ONLY A 6-IN. DEPTH POSSIBLE

is possible. Now instead of considering the duct as 16 in. x 20 in., consider only its effective area of 13 in. x 17 in. or 221 square inches. We likewise consider only 3 in. of the new 6 in. depth as the effective depth. By dividing this into 221 we find the effective width required to be 74 in. to which we must add the three inches of lubricating air to give us the total of 77 in. of duct width.

This simple method, when applied to sheet-metal ventilating ductwork carrying air at from 600 to 1,500 feet per minute will give remarkably accurate results, and permits the engineer to confidently give "on the spot" information, without making it necessary for him to be fortified with a formidable array of charts and sizing tables.

Advantage in Its Use

One great source of trouble in commercial building work is the misdirected zeal of the sheet metal worker, who will cheerfully change sizes on the basis of gross areas in order to accommodate other crafts, with the best of intentions, and later will most naturally and sulkily resent censure for what he had considered a generously performed charitable deed, deserving of commendation.

By giving immediate decisions in the field, the engineer preserves the complete confidence of the construction crew, always a desideratum. This results in him being fully informed in the matter of "field changes" and gives him the advantage of following the construction work in detail—a privilege denied the man who finds it necessary to go back to the office to get required information for the mechanic, which, by a peculiar but potent freak of psychology, is sufficient to cause the field workers to carefuly hide from him any and all traces of liberties taken with the lay-out. A small matter, yes; but what a difference in the testing out of the job—and what a difference in the performance of the equipment!

It must, of course, be understood that the 1½-in. thick "ineffective area" at the duct walls has only a remote resemblance to fact. The conception is, however, a convenient one in this particular application, since a happy combination of causes makes for approximate accuracy of result when used as described.

"Open for Discussion"

Factors to Consider in Evaporator Design—Underground Steam Main Location

The Design of Evaporators

By Edgar E. Ambrosius* and John C. Reed*

AFTER reading Mr. Vetter's article on the design of evaporators[1] in the January issue, we wish to give some additional points worthy of consideration.

It appears that Figs. 1 and 2 may lead the reader to false impressions. These figures apparently intimate that there is very little or no increase in volume as the liquid ammonia passes through the expansion or pressure reducing valve; that is, there is very little or no liquid flashing into vapor immediately after passing through the expansion valve.

Actually, there will be a sudden increase in volume and a portion of the liquid will flash into vapor at the reduced pressure. This would be especially true in the top feed evaporator, Fig. 1, and possibly to a slightly lesser extent in Fig. 2 due to the static head created by the liquid in the evaporator. This expansion phenomenon can easily be shown by means of the temperature-entropy diagram, as shown in Fig. A.

Suppose liquid ammonia at a temperature of 86 F exists on the high pressure side of the reducing valve. This is shown at point *1* and the liquid has a specific volume of 0.02691 cu. ft. per lb. at this condition. Assume that the liquid passes through the valve at a constant heat content, down to 5 F, as is represented by the expansion curve *1, 2*. At this point the liquid ammonia will have a specific volume of 0.02431 cu. ft. per lb. and the vapor 8.15 cu. ft. per lb.

The heat of the liquid at point *1* is 138.9 Btu per lb. At position *2* the heat content of the liquid is 48.3 Btu per lb. and the vapor has 565 Btu per lb.

* Instructor in Mechanical Engineering, University of Illinois, Urbana, Ill.

1. "Factors Affecting the Design of Evaporators," by Herman Vetter. HEATING, PIPING AND AIR CONDITIONING, January, 1931, p. 40.

Then $h_1 = xL_2 + h_2$

or $138.9 = x565 + 48.3$

$$x = \frac{138.9 - 48.3}{565} \times 100 = 16.05 \text{ per cent}$$

That is, under the conditions stated, which are considered standard, 16.05 per cent of the liquid will flash into vapor as soon as it passes through the expansion valve, corresponding to a change in volume from .0269 cu. ft. per lb. to 1.326 cu. ft. per lb. This corresponds to an increase in volume of nearly 50 times which is not shown in either Fig. 1 or Fig. 2 of the article.

The gas velocity curves that accompany Fig. 10 and 11, we feel are not strictly correct. It would have been much clearer had Mr. Vetter designated the vertical distance with a suitable velocity scale.

The arrangement which was given in Fig. 10 as well as Fig. 11 will give a very sudden increase in velocity as the gas leaves the cooler. Fig. 10 should have a velocity curve like the solid line, instead of the dotted line as shown in Fig. B. Should there be a suitable baffle in the liquid trap so that the gas does not blow directly through the trap, Fig. 11 should have a velocity curve similar to the solid line, instead of the dotted line as shown in Fig. C.

Mr. Vetter states that the gas in the suction line often reaches a velocity as high as 2,400 ft. per min. Perhaps this was given as a conservative value and applies to his design, but it has been our observation that it is quite common to find this velocity varying from 2,000 to 4,000 ft. per min.

If one were to represent graphically the temperature conditions encountered in the baudelot cooler, (Fig. 12 of Mr. Vetter's article) they would appear as shown in Fig. D, (liquid feed at the bottom).

If the pressure remains constant the refrigerant will boil at a constant temperature and as the brine or water descends in the cooler it becomes colder; if the refrigerant is fed into the top of the cooler this condition may be represented by reversing the direction of the arrow on the refrigerant curve in Fig. D. The net results are the same as far as heat transfer is concerned, regardless of top or bottom feed. Therefore, we can-

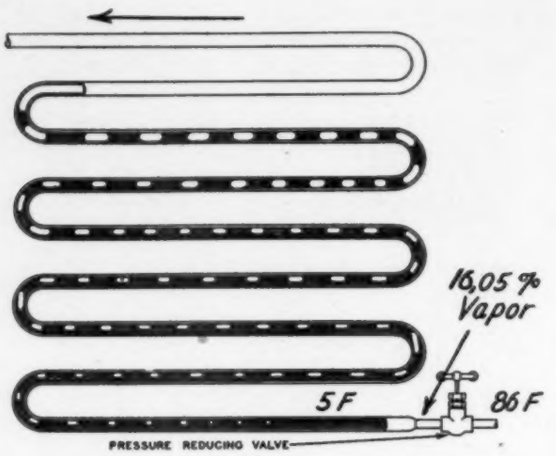


Fig. 1—Direct Expansion Evaporator with Liquid Feed at the Bottom

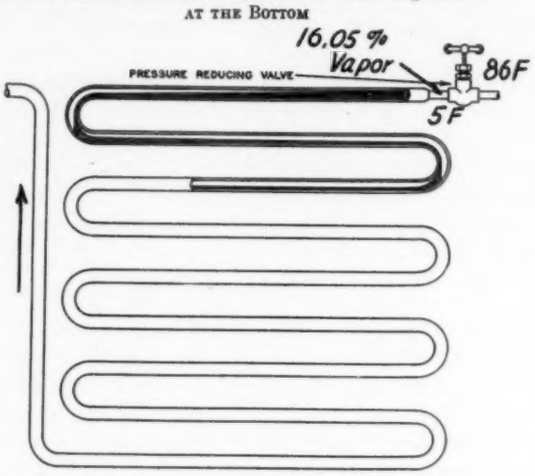
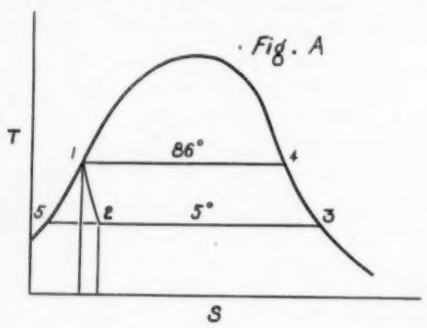


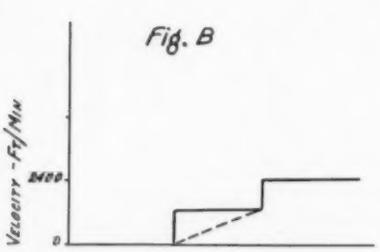
Fig. 2—Direct Expansion Evaporator with Liquid Feed at the Top

not see any material advantage of counter-flow over parallel flow in the baudelot cooler.

In the formula, sq. ft. surface $= \frac{\text{Btu/hour}}{\text{Coeff.} \times T.D.}$, $T.D.$ is defined as the temperature difference between the outside and inside of the evaporator surface. We feel that the average or mean temperature difference of the brine, water or air and the refrigerant should be used in place of the difference of the evaporator surface temperature.

We wonder if it is possible that the coefficients given in Table 2 are to be used only when one has the inside and outside surface temperatures.





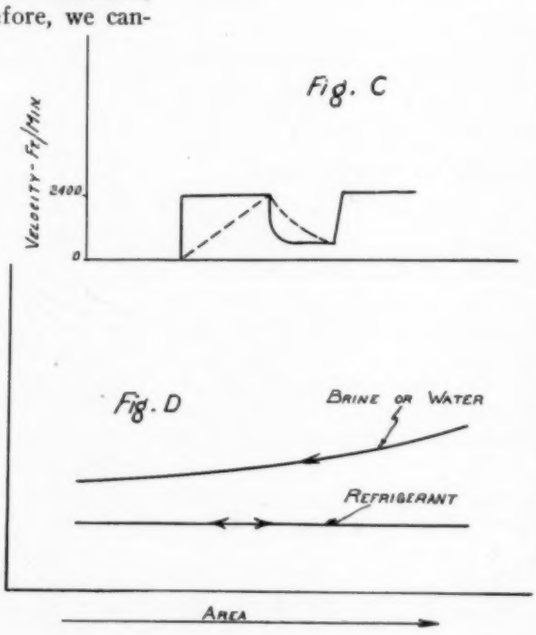


TABLE 2—TYPICAL HEAT TRANSFER COEFFICIENTS

TYPE OF EVAPORATOR	HEAT TRANSFERRED		COEFFICIENT
	FROM	TO	BTU HEAT TRANSFER PER SQ. FT. PER DEG.
Direct Expansion (Fig. 1)	Air	Refrigerant	2.5
Direct Expansion (Fig. 2)	Air	Refrigerant	2.5
Flooded Type	Brine	Refrigerant	15.0
Radiator Type	Brine	Refrigerant	70.0
Boiler Type	Brine	Refrigerant	70.0
Shell and Tube Cooler	Brine	Refrigerant	75.0
Baudelot Cooler	Water	Refrigerant	80.0

It is realized that in calculating the evaporator surface required for a given set of conditions, the coefficient of heat transfer is of vital importance. In Table 2, Mr. Vetter gives 2.5 Btu per sq. ft. per degree, as a value for a direct expansion evaporator with liquid feeds at both the top and bottom (see Fig. 1 and 2). We question this because surely more heat per sq. ft. of surface will be transferred in the coil shown in Fig. 1 than in Fig. 2, for it contains much more liquid. Thomas Shipley has shown that the evaporator having the most wetted surface is the one that will transfer the most Btu per sq. ft. per deg. diff. per hr. Primarily the rate of heat transfer is the most essential factor in the design of an evaporator. For this reason we would think that a direct expansion evaporator with a liquid feed at the bottom as shown in Fig. 1, would give a higher coefficient of heat transfer than one with the liquid feed at the top.

Also we cannot justify the difference of 15 to 75 Btu per sq. ft. per degree, between the flooded type and the shell and tube type evaporator. It seems that the conditions of brine and refrigerant with respect to the surfaces are the same in both types of evaporators. Therefore, we would expect to find similar coefficients for these two types. These coefficients seem low—perhaps they are based upon conditions of earlier design—because the work of Shipley gives test values of 125 to 150 for evaporators of present day design.

In using any coefficient for calculations in the design of equipment, one should be sure that the coefficient chosen applies in that specific case. We feel that Mr. Vetter's values in Table 2 are correct but that he should have given the conditions and limits under which these coefficients are applicable.

Mr. Vetter has very successfully given the most important factors affecting the design of evaporators by enumerating the factors governing the coefficient of heat transfer. We wish to suggest that there are at least two more factors that are of vital importance:

5. Condition of the inside surface of the evaporator.
6. Circulation or velocity of the refrigerant.

The evaporator of a refrigerating plant is of great importance regardless of its type. The refrigeration produced is dependent upon the heat transfer through the evaporator walls. The requirements for the best heat transfer depends also upon the conditions of the inside as well as the outside surface of the evaporator walls. Mr. Vetter has spoken of the outside surface and the circulation of the element being cooled. It is of equal importance, however, to have the refrigerant circulated freely and to have the inside surface free from grease, oil scale, and rust because failure in observing these precautions tends to insulate the surface and cut down the rate of heat transfer, thus defeating the fundamental purpose of the evaporator.

Locating District Steam Mains

By D. S. Boyden*

REGARDING the location of steam mains, too much emphasis can not be placed on the value of preliminary surveys and investigations. Generally the engineering departments of the cities and public service corporations are very willing to co-operate, especially after the fact is called to their attention that it is in their interests to do so, as many times a dangerous or troublesome situation can be avoided by a little preliminary study.

In many cities, unfortunately, there is no engineering board in charge of the apportionment of locations and the location is wholly dependent upon the position of existing structures in the street. In this case the situation is rather more complicated, especially as, owing to changes in street lines and other causes, the pipes and conduits in many cases are not parallel with the street lines.

Location in Sidewalk

While a location in the sidewalk is in many ways very desirable there are several objections. In the first place, when the soil is at all loose and the foundations of the buildings have to be carried down very deep, the construction of the foundations of a new building is very apt to damage seriously steam mains so placed. Poles and standards, while they may not be set deep enough to interfere with the conduit, have to be supported and braced and when there is a lateral pull on them (as in the case of trolley poles) this is sometimes rather difficult.

The depth of sewer connections is dependent on the depth of the basements, and when the conduit is near the building wall it is very difficult to relocate them, as they generally are built solid through the foundations, and in any case it means rebuilding the whole length.

In some cities they allow areaways to extend to the curb and the company is at the mercy of the owner of the abutting property, who naturally is not going to allow pipe to be extended through what he considers his property without compensation of some sort.

Last, but not least, unless there is some regulation as noted in this article[1], when keeping pipes down to a certain minimum depth, it is often times very difficult, if not impossible, to make the service pipe drain from the service valve back to the main where the valve is located in the building, and the building is across the street.

Tunnelling

Mention is made of installation by tunneling. Some municipalities do not allow this, and in wet ground unless more than twenty feet below the surface the advisability of this method is questionable.

* Superintendent, Steam Heating Service Department, The Edison Electric Illuminating Company of Boston.

[1] *Determining the Location of District Heating Mains*, by John F. Collins, Jr., HEATING, PIPING AND AIR CONDITIONING, October, 1930, p. 817.

This is the fourth and last of the articles on the selection of sterilizers for use in hospitals, emergency operating rooms, laboratories, doctors' offices, etc. In this installment the author includes information on sterilizer connections, vents and the prevention of contamination of the sterilized or distilled water.

FIG. 1—A VIEW OF THE BUILT-IN STERILIZERS IN THE NEW SURGICAL PAVILION OF THE MICHAEL REESE HOSPITAL

Selecting Sterilizers

Article No. 4

By Rollo E. Gilmore*

Hot Air Sterilizers

HOT air sterilizers are extensively used by the United States medical department. The construction of the hot air sterilizer is usually of sheet iron, with single, double or triple shell, or jacket, covered with asbestos, or equivalent non-conducting insulation, and provided with an enclosed base and perforated shelves. A built-in gas burner with control valve, mixer, etc., permits the use of either natural or artificial gas, or may be adapted for using kerosene burners. This type of hot air sterilizer is usually equipped with a ventilating chimney in the top, a damper, and sliding ventilators on each end.

With the hot air sterilizer it is possible to obtain temperatures from 175 to 185 C and maintain them throughout the sterilizing chamber when heated with either gas or oil. No automatic regulating is necessary. This sterilizer may also be had in the electric heated type, in which case a three-point snap switch is usually provided and the air sterilizer equipped with multiple heating elements. The temperatures, and wattage consumed, are: For low heat, or 90 C, 275 watts; for medium, or 140 C, 515 watts; and for high, or 205 C, 1,000 watts. A 200-degree centigrade thermometer is usually included with the hot air sterilizer.

The hot air type sterilizer may be had in a number of standardized sizes, several of which have inside dimensions approximately as follows:

WIDTH INCHES	DEPTH INCHES	HEIGHT INCHES	REMARKS
18	9	12	One shelf
24	14	18	Two shelves
30	18	24	Three shelves
36	20	30	Three shelves

Blanket Warmers, Bed Pan and Solution Cabinets

Blanket warmers seldom are included with sterilizers but in some instances are furnished, especially when a saline solution compartment is made a part of the cabinet. Occasionally the cabinet is designed to include bed pans. Cabinets are often made to hold blankets, bed pans and saline solution in the same space. The objection to storing bed pans and urinals in the same cabinet space as saline solution for intravenant work is obvious. Bed pans and urinals when heated are bound to have odors and these will penetrate through the gauze in flask necks, which we must admit is never to be recommended as suitable for injecting into the blood stream.

Cabinets are made with legs or brackets where exposed, or for building in flush as required. They are

* President, Chicago Association of Consulting Engineers; engineer, Schmidt, Garden & Erikson, architects.

usually constructed of insulated walls of 18 gage rust-resisting metal, in both single and double wall designs, with flush soldered joints and single or double ply doors swung on ball-bearing hinges and equipped with eccentric type latches to pull doors up tight.

Shelves for the storage of blankets should be perforated and removable. The solution compartment should have a drained water-tight shelf. Cabinets containing bed pans should be vented to atmosphere for escape of odors. These cabinets are usually designed for the following approximate sizes:

Width Inches	Depth Inches	Height Inches
18	24	72
24	24	72
18	30	72
36	24	72
30	18	72

Cabinets for solution warming only usually are designed for the following approximate sizes:

Width Inches	Depth Inches	Height Inches
18	8	34 or 16
30	8	34 or 16

If steam heated, a ½ in. steam supply and ½ in. steam return and drip should be provided; a waste connection may be provided if desired. If electrically heated, the heating element should be air-tight and provided with a multiple heat switch and should preferably be equipped with a pilot light which notifies the operator when it is in use. In some instances both steam and electricity are used for heating, especially when the steam plant is shut down during the summer months.

A thermostatic temperature regulator is desirable, especially for saline solution use, to cut off the current or steam when the contents reach a specified temperature, which is usually 110 F.

Sterilizer Connections and Service

The roughing-in for sterilizers should extend approximately one and three-quarters inches from the finished wall and should be left capped with the exception of the waste of the exposed hopper type bed pan washers and sterilizers which should extend nine inches from the wall and be capped. In the cases of combination sterilizer mountings the pipe may be brought to common outlets at the back of the apparatus practically flush with the stand.

Steam heating of sterilizers is usually preferable where constant steam pressure is maintained. Steam pressures of from 50 to 60 pounds per square inch should be available at the apparatus to insure efficient and satisfactory operation of the pressure dressing and water sterilizer types. Steam pressure as low as 10 pounds per square inch has been used, but usually is not satisfactory, and a minimum pressure of 35 pounds should be provided for non-pressure apparatus for surgical sterilizers such as bed pan washers and instrument sterilizers and utensil sterilizers. Steam valves should preferably be of the packless type.

Gas heat is sometimes less desirable for use in connection with sterilizers, partly because of the fumes which are objectionable and obnoxious. Where gas is used, however, the gas main should be regulated to give a constant uniform pressure of approximately five inches of water.

Electric heated sterilizers are often selected where the electric current rates are economical for heating, or where the institution generates its own current.

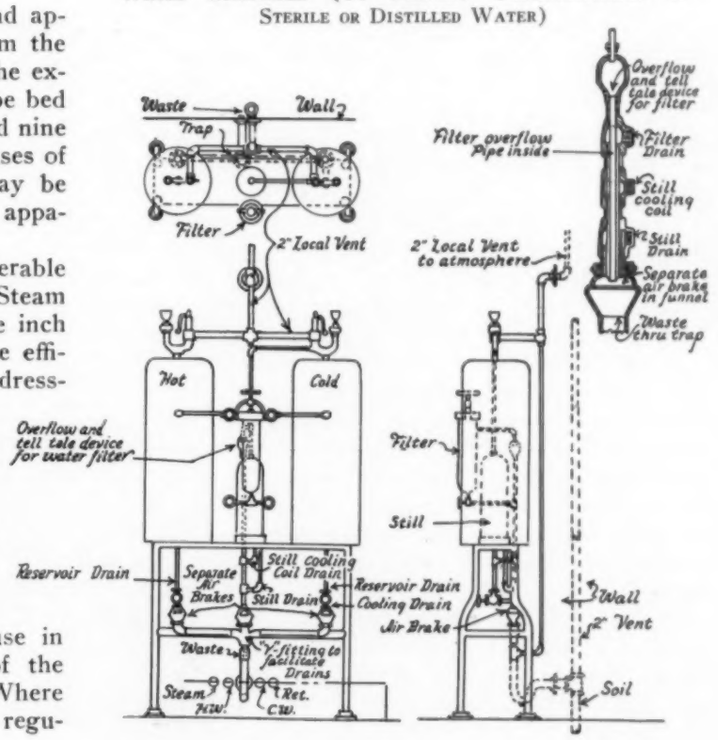
Three heat switches are desirable and full automatic control or thermostats for temperature cut-out should be provided on all electric heated equipment. On the boiling type, one of the cut-offs should be arranged to cut off the current to one heating element when the water reaches the boiling point, and on the others, when the heat rises to a dangerous point, the thermostat should automatically shut off and turn on again when the sterilizer is cooled or when more water is put in.

The current consumption tests are given in the preceding paragraphs under each equipment heading, and generally were based upon 150 F filling water temperature so that for actual operation the figures are low and should be increased possibly 50 per cent to take care of irregularities, including such irregularities as undue wastage of power by prolonged sterilization or by having the current turned on much too high.

Vents

Local atmospheric vents or vapor exhausts from sterilizers should be run to the atmosphere in the shortest possible and unrestricted manner to insure proper draft, complying with the local plumbing code. The local atmospheric vents, if connected to plumbing soil or waste lines, should be connected at a point at least eighteen inches below the main waste connection to eliminate any possibility of the waste water backing up into the utensil or instrument sterilizer through the vent opening.

Fig. 2—Detail of Air Brake, Waste and Funnels on Water Sterilizer (To Prevent Contamination of Sterile or Distilled Water)



Some recommend the omission of a vent, because of the cost and because they are inaccessible for cleaning and inspection. In lieu of the local atmospheric vent, they recommend special devices to condense the excess steam and discharge the condensate to waste lines. These devices can be adapted to the boiling or non-pressure instrument, utensil sterilizers, and milk pasteurizers; they use a small continuous amount of cold water. Many manufacturers of sterilizers have adopted a special fitting for overflow and vent from the non-pressure sterilizers, which acts as a telltale device and immediately indicates when the water supply valve is leaking or improperly closed.

A minimum water pressure of at least 25 pounds is required for the non-pressure or boiling type utensil or instrument sterilizers to insure proper withdrawal of the steam vapors where the ejector type vent valves or devices are used. A ⅜ in. cold water branch connection with a ¼ in. globe valve connection is usually ample for the ejector type condensing vents. Generally a ½ in. water supply line is of ample size to the sterilizers, except where flush valves are used, which require at least a 1-in. water supply.

Preventing Contamination

The possibility of contaminating water systems if there are cross connections in the hospital's plumbing system or in the apparatus connected to it has brought about various protective devices and methods.

Sterilizers should be so piped that water can not siphon back into the water supply should a valve be leaking, or left open, and if the pressure be taken off the line there should be no possibility of water in the sterilizer siphoning back into the water supply.

A breaker or waste funnel should be provided on the waste so that the contents of the sterilizer can not become contaminated should the waste become choked, causing a back pressure. Special bleeder-type water inlet valves have been designed. When a bleeder valve is open the bleeder is closed; when the valve is closed the bleeder is open, so that should the valve be leaking or improperly closed the raw water will drain to the bleeder and will not reach the sterilizer.

The water piping should be carefully laid out, designed, and connected in a manner to resist and prevent siphonage from sterilizer chambers. The overflow pipe should be connected to the drain from the bottom of the sterilizer tank. The overflow pipe on non-pressure sterilizers should be of ample size to carry off all water that can be delivered with the water fill wide open and at a pressure of at least 40 pounds without permitting the sterilizer to overflow on the floor. The breaker or overflow vent will prevent drain water from backing up into the tank under a back pressure. Either an atmosphere or condenser vent should be connected to the overflow pipe at the vent opening in the rear to carry off condensation. In some localities the condition of the water leaves deposits on the instruments unless it is first filtered, so that an analysis of the water to be used should be made.

The trend and practice recommended today is to design and make all the connections to the sterilizing apparatus so that no contamination of the water supplies is possible under any and all extreme conditions.

Steam Demand

In arriving at the sizes of the high pressure boiler for the hospital, it is necessary that we know the steam consumption per hour for all the sterilizers. About 40 per cent to 50 per cent of the total maximum should then be used as a safe working demand inasmuch as it will be very seldom that all the sterilizers will be operated at the same time, and also on account of the fact that the steam consumption drops off very rapidly as the sterilizers and their contents heat up to a temperature equal to or above the boiling point of water. For example, consider a battery of sterilizers:

One 16 in. diam. by 36 in. dressing sterilizer	50 lb. per hr.
Two 25 gal. water sterilizers	250 lb. each tank per hr.
One 8 by 10 by 20 inst. sterilizer	100 lb. per hr.
One 24 in. x 20 in. x 20 in. utensil sterilizer	150 lb. per hr.
Total	800 lb. per hr.

40 per cent of total = 320 lb. per hour.

Therefore, 320 lb. of steam per hour will be required and this is equivalent to approximately 10 boiler horsepower which is usually ample for the size of the battery of sterilizers referred to, provided the steam pipes are well insulated and are run as directly as possible from the boiler to the sterilizers.

Sterilizer Tests

A practical test to determine the efficiency and accuracy of dressing sterilizing apparatus for complete penetration and destruction of the most virulent spores, and safeguard against infection can be made by melting Diack Controls, which are placed in the center of a drum, or in the center of a package. These melt after a temperature of 254 F has been reached for five minutes, or after 244 F has been attained and maintained for twenty-five minutes or more.

These controls consist of a fusible tablet in a sealed tube. The tablet will melt only under sterilizing conditions. When placed at the center of every large package or drum it will give visible proof as to whether heat has penetrated it or not. This is a check on the sterilizer gage.

Another method of testing is through the use of a maximum lag registering thermometer, 100 to 300 F, which may be placed in the bundles and will record the highest temperature reached in the center of the bundle. These tests are recommended by many hospital authorities, as a matter of routine. Recording gages are recommended by some, as the gage records and indicates that the sterilizing temperature was maintained for a definite time.

Heating·Piping
and Air Conditioning

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The Measurement of the Flow of Air Through Registers and Grilles

PART II

By L. E. Davies,[1] Chicago, Ill.
NON-MEMBER

This paper is the result of research conducted at Armour Institute of Technology of Chicago, in cooperation with the A. S. H. V. E. Research Laboratory and the Ventilating Contractors Employers Association of Chicago

THE initial report covering the research work conducted in the Laboratories of the Armour Institute of Technology to determine the most satisfactory method of measuring the air passing through a register or grille, was presented at the 36th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Philadelphia, Pa., January, 1930.[2] It appeared from this investigation that the only feasible device to be used for this purpose was the anemometer, and the problem therefore resolved itself into a study of that instrument.

For purposes of the investigation a centrifugal fan and a system of ducts were arranged in such a manner that the same air which passed through the grille also passed through a length of straight round duct in which Pitot tube traverses were made simultaneously with anemometer traverses at the face of the grille. Tests were conducted with the ducts and grilles both on the exhaust and discharge sides of the fan.

The tests previously reported were made entirely with one type of anemometer and were confined generally to thin lattice work grilles with various percentages of free area, although a few observations were taken with expanded metal lath, and with thick iron having circular openings.

The following conditions which were not considered in the original study were included in the investigation covered by the present report:

1. To study some of the more ornate forms of grilles, particularly the ornamental plaster type.
2. To use the various types of anemometers on the market to determine whether or not the formulae previously derived could be applied equally well to all types.
3. To make tests at higher velocities than those previously attained.
4. To have traverses made by various individuals, particularly by those previously unfamiliar with the instrument, to determine the importance of the personal element.

In the earlier work it was found that with supply grilles the following formula could be used:

$$\text{cfm} = \frac{CV(A + a)}{2} \qquad (1)$$

in which

cfm = volume of air in cubic feet per minute.

V = average indicated velocity obtained by anemometer traverse taken in contact with grille (after applying anemometer correction).

A = gross area of grille—square feet

a = net free area of grille—square feet

C = coefficient determined by experiment

The value of C was 0.952 at 150 ft per minute and approached 1.00 as the velocity increased. Thus, for most of the practical work a value of 1.00 is sufficiently accurate which makes the formula a very convenient one.

On exhaust work the results were not quite as satisfactory as somewhat different values of C were obtained with the different grilles. However, by means of an average value of C which varied with the velocity it was possible to obtain quite accurate results.

The following alternate formula, which was applicable only in the case of exhaust grilles, was also submitted:

$$\text{cfm} = KVA \qquad (2)$$

in which

V = average indicated velocity obtained by the anemometer traverse in contact with grille

A = gross area of grille—square feet

K = coefficient determined by experiment

The average value of K in formula (2) was 0.8, while for more accurate results a value ranging from 0.762 at 150 ft per minute to 0.832 at 700 ft per minute was recommended, with the value apparently approaching a constant figure at the higher velocities. At the time these two formulae were submitted there appeared to be little choice between them as to accuracy, neither one of them giving results as consistently accurate as those obtained with supply grilles, but both of them a great deal better than previous methods of calculation.

Figs. 1 to 4 show the types of grilles covered by this report. Fig. 1 shows a grille having the same face design and percentage of free area as one originally tested, but differing in that it was of cast iron several times thicker than the former one and having the usual tapered frets characteristic of castings. The gross area also differed somewhat from any grilles previously used.

Fig. 2 shows a familiar type of thin iron grille having a conventional ornamental design. Figs. 3 and 4 show two plaster grilles of quite different design. Fig. 3 is characterized by the fact that the large center portion has an extremely small amount of free area, while the four corners have open spaces as large as the anemometer. Certain portions of the pattern also were raised above the general surface level, so that it was impossible to keep the anemometer in intimate contact with the face of the

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[2] See Journal of The Society (HEATING, PIPING AND AIR CONDITIONING), January, 1930.

grille at all times. The thickness of this grille was approximately the same as that of the cast-iron grille shown in Fig. 1. Fig. 4 shows a design which is distinguished by the largeness of the details. It is very thick, has rounded edges, and has both large free spaces and large solid portions.

conducted in the same manner as described in the original report.[3] In the case of the iron grilles, the individual values of C and K varied above and below the curves shown by about the same amount obtained in the earlier tests, but in the case of the plaster grilles this variation was somewhat greater though not to a serious

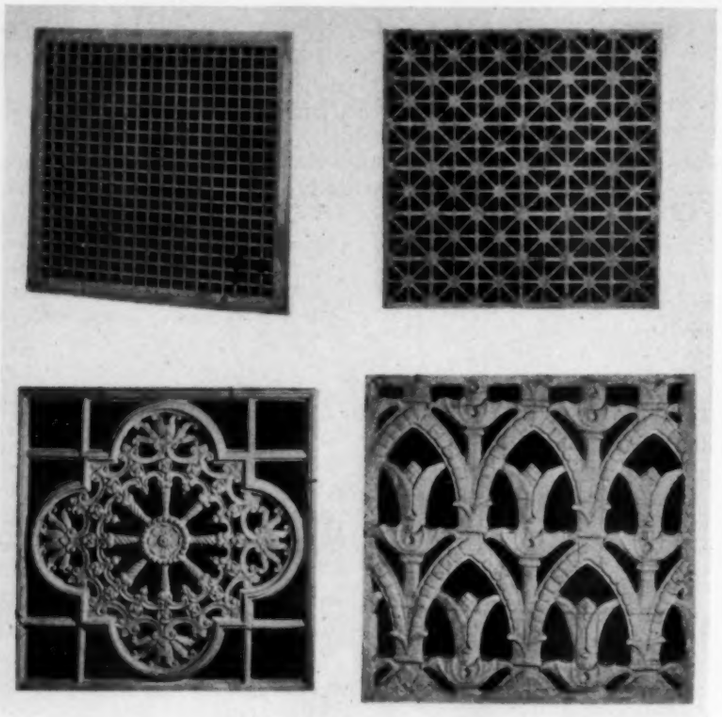

FIG. 1—CAST IRON GRILLE HAVING FREE AREA OF 60.5 PER CENT

FIG. 2—THIN IRON GRILLE OF CONVENTIONAL ORNAMENTAL DESIGN HAVING FREE AREA OF 54.8 PER CENT

FIG. 3—PLASTER GRILLE HAVING FREE AREA OF 43.0 PER CENT

FIG. 4—PLASTER GRILLE HAVING FREE AREA OF 34.2 PER CENT

Exhaust Grilles

The results obtained with the different types of grilles on exhaust are shown by the curves of Figs. 5 and 6. These curves were plotted from a large number of tests degree. The results are summarized in Tables 1 and 2. Table 1 shows the results obtained when using formula (1). It will be noted that the results obtained with the two iron grilles were in close agreement with the earlier

[3] See Journal of The Society (HEATING, PIPING AND AIR CONDITIONING) January, 1930.

TABLE 1—SUMMARY OF RESULTS WITH EXHAUST GRILLES WHEN USING FORMULA

$$\text{cfm} = CV\left(\frac{A+a}{2}\right)$$

GRILLE USED	INDICATED VELOCITY fpm	C (FROM CURVES)	PERCENT ERROR WHEN USING $C=1.02$	PERCENT ERROR WHEN USING C FROM PREVIOUSLY RECOMMENDED VALUES	PERCENT ERROR WHEN USING FORMULA cfm $= Va$
1. Cast Iron.....	150	0.997	+2.2	−0.3	−24.5
	400	1.012	+0.6	+3.5	−25.5
	700	1.021	−0.1	+6.0	−26.2
2. Ornamental Iron.	150	0.998	+2.1	−0.4	−26.6
	400	1.060	−4.0	−1.0	−31.4
	700	1.097	−7.0	−1.0	−34.2
3. Ornamental Plaster.....	150	1.040	−2.0	−4.5	−40.5
	400	1.119	−8.8	−6.0	−44.4
	700	1.181	−13.8	−8.2	−47.0
4. Ornamental Plaster.....	150	1.075	−5.2	−7.5	−56.0
	400	1.152	−11.5	−9.0	−58.5
	700	1.211	−16.0	−10.5	−59.7

TABLE 2—SUMMARY OF RESULTS WITH EXHAUST GRILLES WHEN USING FORMULA

$$\text{cfm} = KVA$$

GRILLE USED	INDICATED VELOCITY fpm	K (FROM CURVES)	PERCENT ERROR WHEN USING $K=0.8$	PERCENT ERROR WHEN USING K FROM PREVIOUSLY RECOMMENDED VALUES	PERCENT ERROR USING FORMULA cfm $= Va$
1. Cast Iron.....	150	0.801	−0.1	−5.0	−24.5
	400	0.813	−1.5	−0.6	−25.5
	700	0.820	−2.5	+1.4	−26.2
2. Ornamental Iron.	150	0.748	+7.0	+1.9	−26.6
	400	0.799	+0.1	+1.0	−31.4
	700	0.834	−4.0	−0.2	−34.2
3. Ornamental Plaster.....	150	0.724	+10.5	+5.0	−40.5
	400	0.773	+3.2	+4.1	−44.4
	700	0.814	−0.5	+2.1	−47.0
4. Ornamental Plaster.....	150	0.779	+2.9	−2.0	−56.0
	400	0.824	−2.8	−2.0	−58.5
	700	0.848	−5.6	−1.9	−59.7

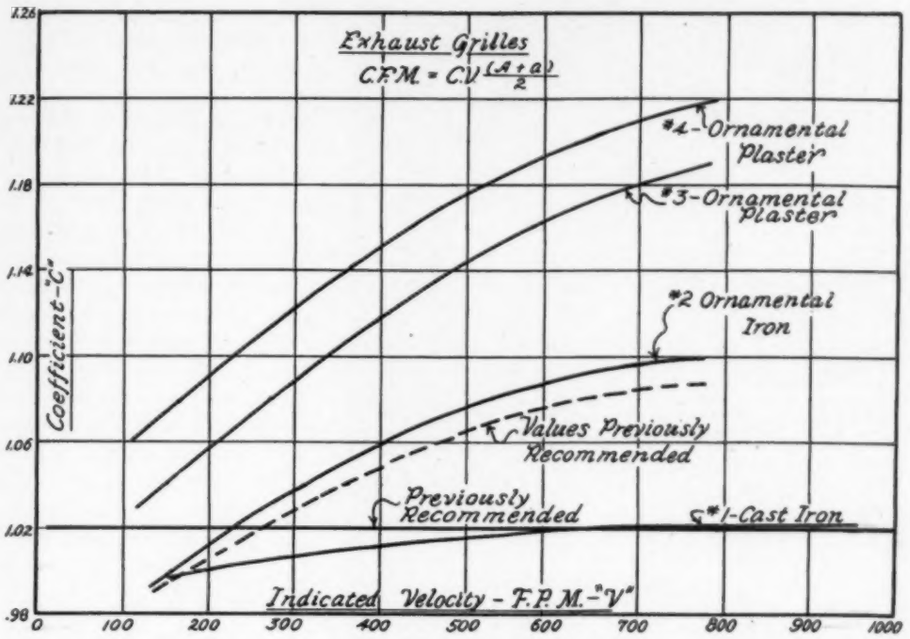

FIG. 5—VALUES OF COEFFICIENT C FOR EXHAUST GRILLES AT VARIOUS INDICATED VELOCITIES

results except that the curve for the cast-iron grille is much flatter than any of the others. The results obtained with the plaster grilles were less satisfactory although these results were a great deal more accurate than those obtained by means of the earlier methods of calculation, as can be seen by a comparison with the figures in the last column.

The percentage of error when using formula (2) is considerably less as shown by Table 2. So far as the iron grilles are concerned there is little choice between the two formulae, but with the plaster grilles the results obtained with formula (2) are much more accurate.

Considering all of the work completed up to the present time, formula (1), when used with the recommended values of C for the various velocities, gives maximum errors of ± 11 per cent while formula (2) with recommended values of K reduces this error to ± 5 per cent. When using constant values of 1.02 and 0.8 respectively, formula (1) will be subject to errors of from +13.5 per cent to —15.5 per cent, while formula (2) will give results varying from +11 per cent to —7 per cent. From these figures it is apparent that formula (2) is to be preferred for exhaust measurements. It is rather fortunate that this is the case as a knowledge of the percentage of free area is not required. This latter value is extremely difficult to measure or estimate with any degree of accuracy when the grilles are elaborate in design, so that any formula involving the free area would necessarily be subject to the errors made in the measurement of that value.

Supply Grilles

It is unnecessary to show curves or elaborate data covering the work done on the two iron grilles when used for supply. The results coincided exactly with the results obtained in the earlier tests. The results obtained with the ornamental plaster grilles when tested on the supply end, however, were less satisfactory inasmuch as the values of C for these grilles were considerably below

TABLE 3—TESTS ON ORNAMENTAL PLASTER SUPPLY GRILLES

Grille No.	Indicated Velocity fpm	Pitot Tubes cfm	Anemometer Traverses						
			Va		VA		$V\left(\frac{A+a}{2}\right)$		C
			cfm	Percent Error	cfm	Percent Error	cfm	Percent Error	
3	349.5	802	578	−28	1,344	+68	961	+20	0.834
4	300	556	411	−26	1,200	+116	805	+45	0.690
	566	1,130	775	−31	2,264	+100	1,519	+34	0.744
	891	1,785	1,222	−32	3,564	+100	2,393	+34	0.746

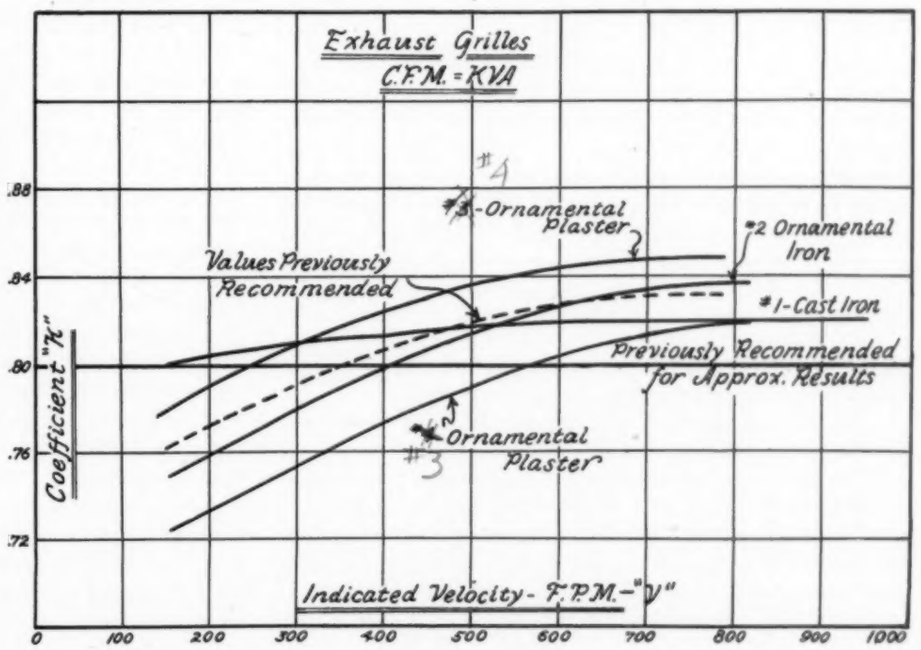

FIG. 6—VALUES OF COEFFICIENT K FOR EXHAUST GRILLES AT VARIOUS INDICATED VELOCITIES

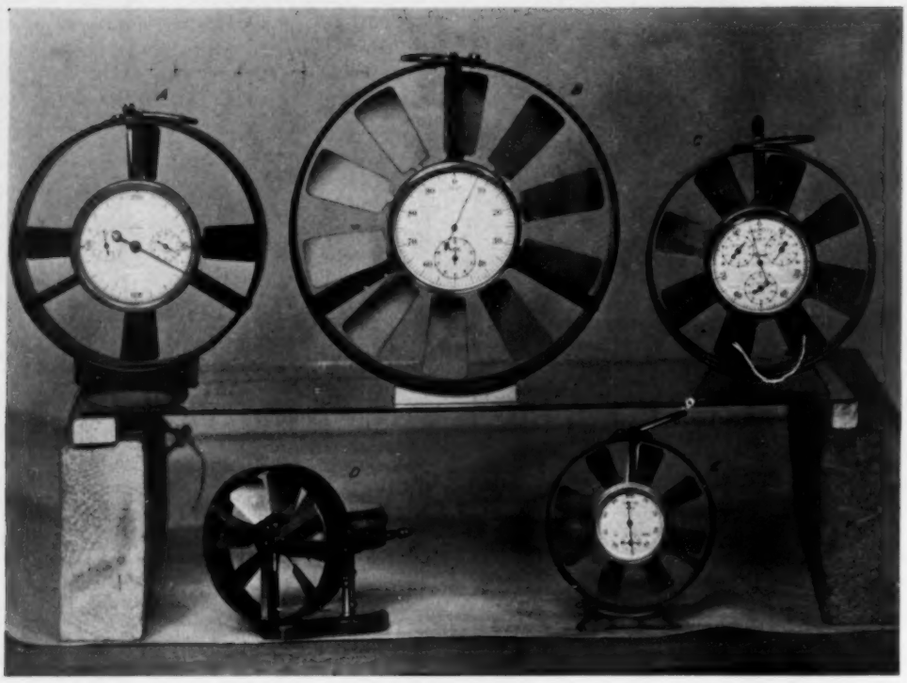

FIG. 7—TYPES OF INSTRUMENTS TESTED

TABLE 4—COMPARISON OF ANEMOMETERS

TYPE	FACE DIAMETER, INCHES	RATED VELOCITIES FEET PER MINUTE	RELATIVE VALUES OF C OR K
a	4.37	500 to 6,000	1.00
b	6.00	75 to 500	1.04
c	4.00	200 to 3,000	1.00
d	2.75	200 to 3,000	0.98
e	3.00	200 to 1,000	0.98

1.0 in the recent tests, whereas in every other case they were very close to this value. It has not been possible to give a satisfactory explanation of this fact. The results of a few of the observations made on these grilles are shown in Table 3.

It will be noted that with the grille shown in Fig. 4, the first condition was encountered under which the results obtained with formula (1) were less accurate than with the earlier method, namely that of multiplying the indicated velocity by the net free area. Many runs were made with variations in the method of taking the traverse and with the different types of anemometers, but with substantially the same results. The only consolation in these unsatisfactory results lies in the fact already discussed, namely, that the difficulty in determining the amount of free area with this type of grille would make the results more or less inaccurate even though the method were inherently correct. It appears both desirable and necessary to devise some better method of handling this type of grille. The author is engaged at the the present time in the development of such a method and has recently obtained encouraging results.

Some time has been devoted to the study of higher velocities ranging upward to 1600 ft per minute. As anticipated, the increases in the values of C were very slight. This fact was recently verified in connection with a unit heater test. The heater was of the draw-through type and discharged the air through a nozzle-like outlet 24 x 6 in., in which were mounted numerous adjustable horizontal and vertical baffles. These baffles were flat and when adjusted properly gave an extremely uniform air flow, with a velocity of about 2200 ft per minute. The straight uniform flow, together with the high velocity, made it possible to take Pitot tube readings at the outlet. The volume of air per minute as calculated from these readings checked perfectly with the value obtained from an anemometer traverse when using the factor 1.0 in the formula. Furthermore, a very good heat balance served to verify the accuracy of the measurements.

Comparison of Anemometers

All of the work discussed so far has been executed with the 4-in. American made instrument of Type *c* in Fig. 7. During the course of the work three of these instruments were used. Through the courtesy of the manufacturers, one of each type handled by them was obtained. Table 4 identifies the various instruments used.

Direct comparisons were made between the various instruments, that is, the traverses with the instruments being compared were made in rapid succession without any change in the conditions. The results obtained were rather interesting in that it appears that the coefficients are, to a small degree, a function of the face diameter. Under identical conditions the two smallest instruments invariably agreed very closely in their indicated velocities, with the smallest one tending to show the largest reading. The difference, however, was very slight in spite of the radical difference in their design. Similarly type *c* and type *a*, the high velocity instruments, checked each other perfectly, but with all readings averaging approximately 2 per cent lower than the smaller instruments. The greatest discrepancy occurred between the 4 in. and the 6 in. low velocity types. The latter indicated velocities averaging about 4 per cent lower than the former. The last column of Table 4 shows the effect of these variations on the value of the coefficient. Since the normal value of C is less than 1.00 at velocities within the range of the 6-in. anemometer, it is suggested that a coefficient of 1.00 always be used with this type of instrument, in which case the errors will be compensating ones, and the resulting net error reduced to a small value.

As a test of the importance of the personal element, during the past few months 17 groups of students, four men in each group, repeated some of the work, using various grilles, anemometers, and both exhaust and supply ducts. Each group secured two sets of data. In each case, careful instructions were given as to exactly what was to be done, and the Pitot tubes and draft gages were properly adjusted and the students then left to their

own resources. In spite of the fact that most of these men had never handled an anemometer before, there were only three results out of the total of 34 that were farther from the average curves than the author's tests had been. This indicates that when a definite method of procedure is outlined and followed the personal element is largely eliminated. Unfortunately, many times the worker is impatient and desires to secure results with a minimum expenditure of time and effort. In such cases he will take a very hurried moving traverse with the result that his figures are unreliable. As previously stated, a moving traverse may be made accurately providing enough time is allowed and a uniform speed is maintained.

It is when unusual conditions are encountered and the testing engineer must depend upon his own judgment that the personal element becomes of greatest importance. It is safe to say that no set rules or formulae can be devised that can be used with absolute accuracy under all conditions. The good judgment of an intelligent man is an essential part of every test whether it be in air measurements or in any other branch of engineering.

Measuring the Temperature of Flames

The temperature of solids may be estimated by the eye or accurately measured by means of a thermometer, thermocouple, or optical pyrometer. Flames, particularly non-luminous flames, present a more difficult problem. A flame may be hot enough to melt platinum and yet look fairly cool to the eye; conversely, there are certain luminous cool flames which will not burn the hand. This is because the radiation from flames does not follow the laws which apply to solids; for example, much of the radiation from the ordinary Bunsen type of flame is in the invisible infra-red region of the spectrum.

In a method for measuring flame temperature being employed at the Pittsburgh Experiment Station of the United States Bureau of Mines, Department of Commerce, the flame is colored yellow with sodium vapor and the intensity of this light compared in a spectroscope with the light from a heated solid at known temperature. The work is being carried out as one phase of a study of the physics and chemistry of gaseous combustion and explosion. Values have been obtained for stationary flames of different mixtures of air with methane, ethane, propane, butane, isobutane, ethylene, propylene, and butylene. Maximum flame temperatures vary from 1880 C for methane to 1975 C for ethylene. The mixture of gas and air which gives maximum temperature does not correspond to that which gives maximum flame speed except for methane and Pittsburgh natural gas. For all other hydrocarbons tested, the mixtures which produced the highest flame temperature contain less combustible gas than those which give the highest speed of flame. The percentage of combustible gas in air which gives maximum flame temperature is slightly on the rich side of that required for exact combustion to carbon dioxide and water. Maximum calculated temperatures are 40 to 70 deg. (C) higher for the saturated hydrocarbons and about 100 deg. higher for the unsaturated hydrocarbons than the experimental values. Radiation losses account for the lower measured temperatures.

Constant Temperature Drying Room

In handling a large volume of coal analysis it is essential that the coal be air-dried at a temperature of 30 to 35 C before being pulverized to eliminate the loss of moisture in sampling. Recently a constant temperature room 6 by 6 by 7 ft. was constructed at the Pittsburgh Experiment Station of the United States Bureau of Mines in which the temperature has been maintained at 32 to 34 C through the summer months when the outside temperature was 35.0 to 42.8 C.

Pneumatic Cleaning Plants for Coal

An action unique in the history of the safety movement has just been taken by the *American Standards Association* with the approval of a national accident prevention code for a process in which not a single serious accident has yet occurred. The new code is aimed at the prevention of dust explosions in pneumatic cleaning plants for coal, according to an announcement made recently by the Association. Practically all coal was formerly washed with water. It was found, however, that cleaning could be done more efficiently with air.

Each of the fifty other national safety code projects completed or in process of development under the auspices of the *American Standards Association* has followed a long series of fatalities or injuries or a spectacular disaster which led the industry concerned to request the establishment of a safety code. In the case of coal pneumatic cleaning plants, the use of which started only a comparatively few years ago, however, there has not been a single serious dust explosion. It was the belief of the industry and of safety experts that the potential hazard was great enough to warrant the development of a national code which would provide every possible safeguard against disastrous dust explosions. Dust explosions have frequently occurred in coal mines and grain elevators, and in factories where pulverizing processes may, without proper safeguards, fill the air with a fine explosive dust.

The work on the preparation of the code was carried on by a technical committee under the direction of the U. S. Department of Agriculture and the *National Fire Protection Association*. The technical committee has completed safety codes for the prevention of dust explosions in grain elevators, flour and feed mills, starch factories, pulverizing systems for sugar and cocoa, and in pulverized fuel systems. The code contains comprehensive provisions for the construction and ventilation of buildings in which pneumatic screening and cleaning equipment and driers are located and for the safeguarding of equipment, and methods of dust collection.

Government Printing Office Affiliates with A S A

The affiliation of the United States Government Printing Office, Washington, D. C., the largest printing plant in the world, with the *American Standards Association*, was announced recently. The Government Printing Office is the eighth division of the federal government to become a member of the Association participating in the direction of national standardization work.

The Use of Gas for House Heating

By H. B. Johns,[1] Chicago, Ill.
MEMBER

THE purpose of this paper is to acquaint the heating engineer with the application of gas as a fuel for heating homes. In order more fully to understand the use of gas as a fuel, a brief discussion is given of the manufacture and distribution of gas before going into the matter of its utilization.

Types and Sources of Gas

There are two general types of gas available in this country, namely, natural and manufactured.

Natural gas is obtained from wells and usually is found stored in the same *pocket* with oil. The calorific value of natural gas is comparatively high, ranging from 1,000 to 1,100 Btu per cubic foot. The gas often contains a number of different hydrocarbons, but methane almost always is present in the greatest proportion—usually about 90 per cent. As compared to the manufactured variety, natural gas has a somewhat slower rate of flame propagation, that is, it does not burn as rapidly as manufactured gas. Natural gas usually sells for 50 or 60 cents per 1,000 cu ft for such purposes as house heating.

Manufactured gas is obtained either from the destructive distillation of coal or by the action of superheated steam on hot coke. In the former case, the product is known as coke-oven gas and the latter as blue gas or water gas. Water gas usually is enriched with gaseous hydrocarbons obtained by an oil cracking process. Manufactured gas usually has a heat content of 500 or 600 Btu per cubic foot and sells at from 70 cents to over $1.00 per 1,000 cu ft for house heating. It is to be noted from these figures that the price of natural gas per 1,000 Btu of heat value is about one-third or one-fourth that for manufactured gas.

Distribution of Gas

In order to absorb the peaks and valleys of the daily send-out (see Fig. 1), gas is stored in holders. In this way the generating plant or pipe line pumping stations will have a fairly steady load through the 24 hours of the day.

Two types of low pressure holders are in common use: the older water sealed lift type (Fig. 2) and the newer waterless floating piston type (Fig. 3). In both types the gas is stored under a gage pressure of about 5 oz per square inch (8 or 10 in. of water). For high pressure storage, steel tanks in the shape of spheres or *sausages* are used. Storage pressures as high as 150 lb per square inch are frequently used in this type of holder.

Gas is delivered to the consumer at a pressure of 3 or 4 oz per square inch (5 to 7 in. of water). This pressure is kept quite constant by a network of high- and low-pressure mains which are controlled by pressure regulators.

Equipment for Heating Homes with Gas

Two methods of applying gas burning equipment to heating systems in homes are in common use. One is to install a boiler or furnace designed especially for gas,

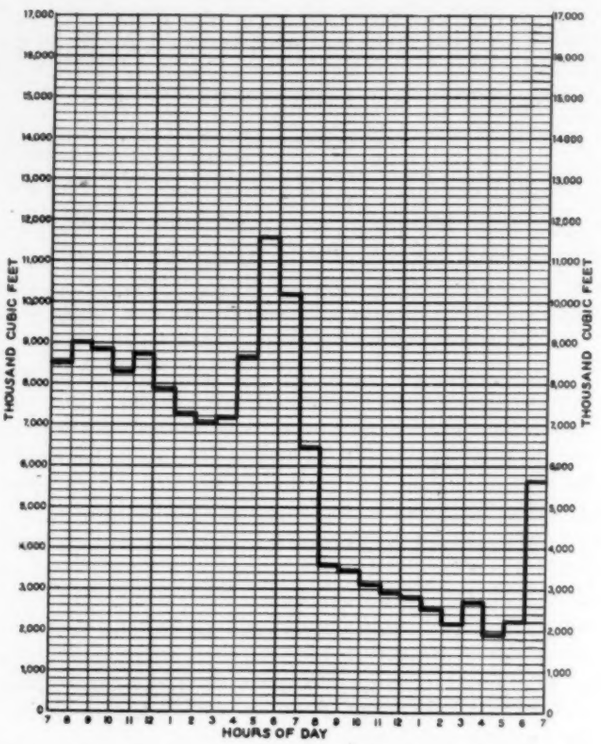

FIG. 1—TYPICAL DAILY LOAD CURVE SHOWING VARIATION IN AMOUNT OF GAS DISTRIBUTED PER HOUR

and the other is to install a conversion burner in an appliance which is designed to burn some other fuel.

In connection with the use of equipment designed to burn gas exclusively, the *American Gas Association,* through its testing laboratory, has set up certain standards of performance and construction. Approval by this laboratory indicates that the gas-fired boiler or furnace has met certain standards of safety and operating efficiency and that it burns gas at a certain rate without showing the presence of carbon monoxide in the flue products. The minimum acceptable thermal efficiency for water and steam boilers is 75 per cent and for warm air furnaces is 70 per cent, based on the gross or entire heat value of the gas. Fig. 4 shows a gas-fired boiler for a hot water system, and Fig. 5 shows a cutaway view of an automatic warm air unit showing construction and

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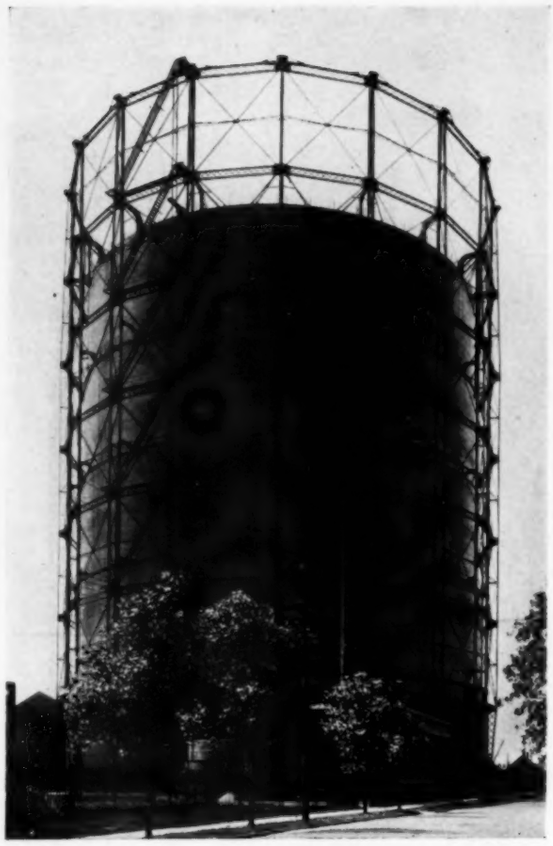

FIG. 2—LIFT TYPE OF HOLDER SEALED WITH WATER

arrangement of filters, fan, fan drive, cast-iron sections, baffles and humidifier.

Several manufacturers of gas-fired boilers and furnaces have designed their equipment so that burner cocks and other control equipment are completely hidden from view, and the exterior of these appliances presents a stream-line appearance. This feature enables the architect and heating engineer to give his client a heating system which will require a minimum of space in the basement, and at the same time does not detract from the appearance of any special rooms which might be built into the basement.

Since gas burns with a non-luminous flame which produces relatively little radiant heat, it is necessary to construct boilers and furnaces with ample secondary heating surfaces in order to *scrub* or *wipe* the heat out of the combustion products. In converting boilers designed to burn solid fuel, it frequently is found that the heating surface is inadequate to obtain a satisfactory operating efficiency and it is then necessary to introduce refractory materials and baffles so that as much radiant heat as possible will be developed and to be sure that all heating surfaces are utilized to the fullest extent. This problem is encountered especially when converting the smaller round boilers. Fig. 6 shows a conversion gas burner installed in a warm air furnace.

On account of the flexibility of gas as a fuel and the ease with which it can be controlled, both conversion burners and gas-designed equipment are usually completely equipped with automatic control equipment. For operation with steam and vapor heating systems, steam pressure limit controls and low water protection devices are used. For hot water, a water temperature limit control is used. Practically all gas-fired installations use a room temperature control and automatic safety pilots are available for use with any type of system, whether steam, hot water or warm air. Practically all of the gas-fired, warm-air furnaces have automatic humidifying apparatus as part of the standard equipment. Recently several manufacturers have produced warm-air furnaces which include blowers and filters in addition to the humidifying equipment.

Selecting the Equipment

In determining whether gas designed or conversion equipment is to be used on a given installation, it must be borne in mind that for most of the moderately-sized installations the use of fuel will be about 10 per cent greater if conversion equipment is used. Hence, it usually is best to use gas-designed equipment when making an installation in a new building. In an old building, however, one must determine whether the greater interest and investment charges encountered in a gas-designed installation are more than offset by the greater operating cost resulting from the use of a conversion burner.

In selecting the proper sized boiler or burner for hot water or steam installations, it is desirable, of course, to have sufficient capacity in excess of the radiation or heat loss requirements to heat the building quickly in the event the room temperature is permitted to get too low.

Table 1 gives the selection factors recommended by the *American Gas Association*. This table indicates the amount to be added to the equivalent direct steam radiation and a boiler or heater of the nearest higher *American Gas Association* rating would be selected as having the proper capacity.

Since warm air heating systems respond very quickly

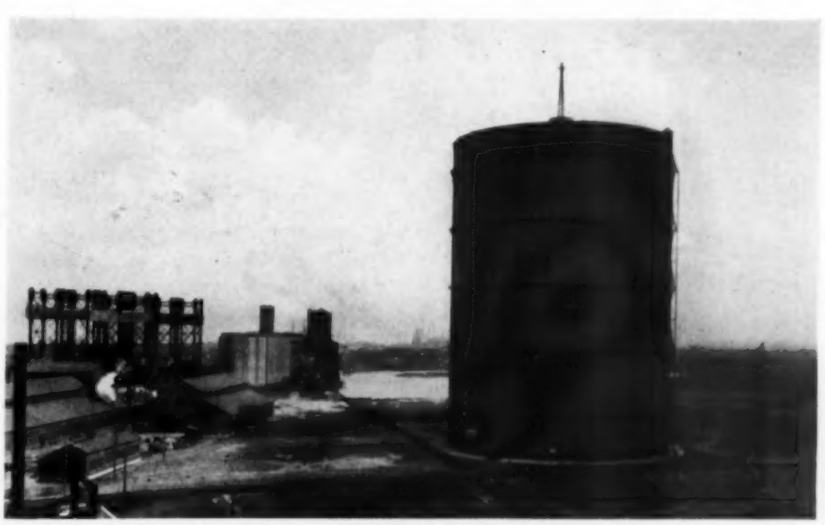

FIG. 3—NEW OR WATERLESS TYPE OF GAS HOLDER. THIS TYPE IS IN USE IN CAPACITIES UP TO 20,000,000 CU FT. THE FLOATING PISTON ON THE INSIDE OF THE HOLDER IS SEALED WITH A STREAM OF FLOWING TAR

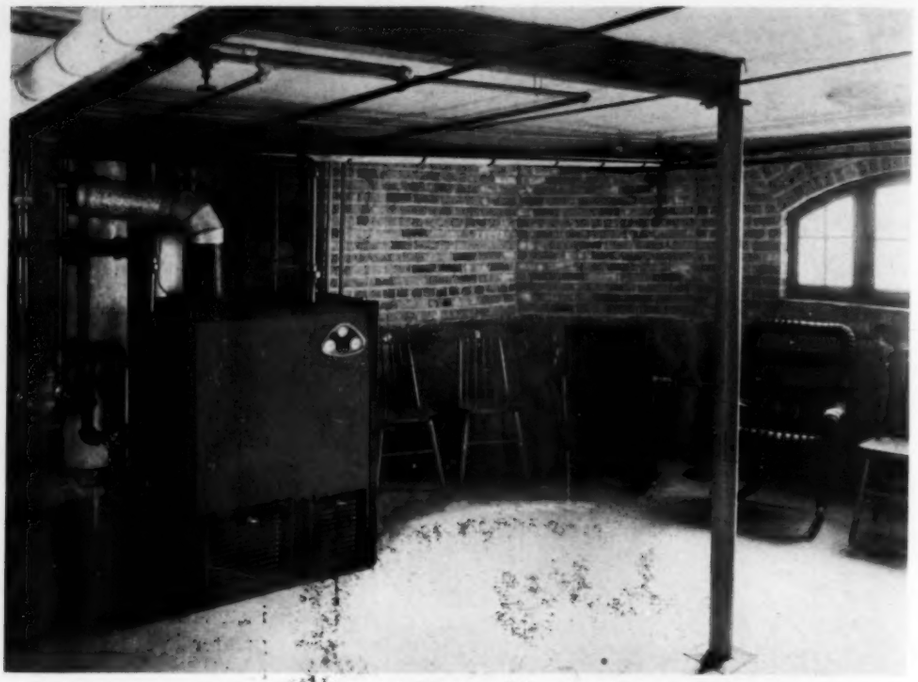

FIG. 4—APPLICATION OF GAS TO A HOT WATER HEATING SYSTEM SHOWING THE ATTRACTIVE APPEARANCE OF THE BOILER WITH ALL WORKING PARTS CONCEALED

TABLE 1—SELECTION FACTORS FOR GAS BOILERS

RADIATION LOAD (SQUARE FEET)	SELECTION FACTOR
100	0.56
500	0.56
1000	0.523
1500	0.486
2000	0.45
2500	0.437
3000	0.424
3500	0.412
4000 (and over)	0.40

and the piping load is not great, many gas companies use selection factors of 25 or 30 per cent for warm air furnaces.

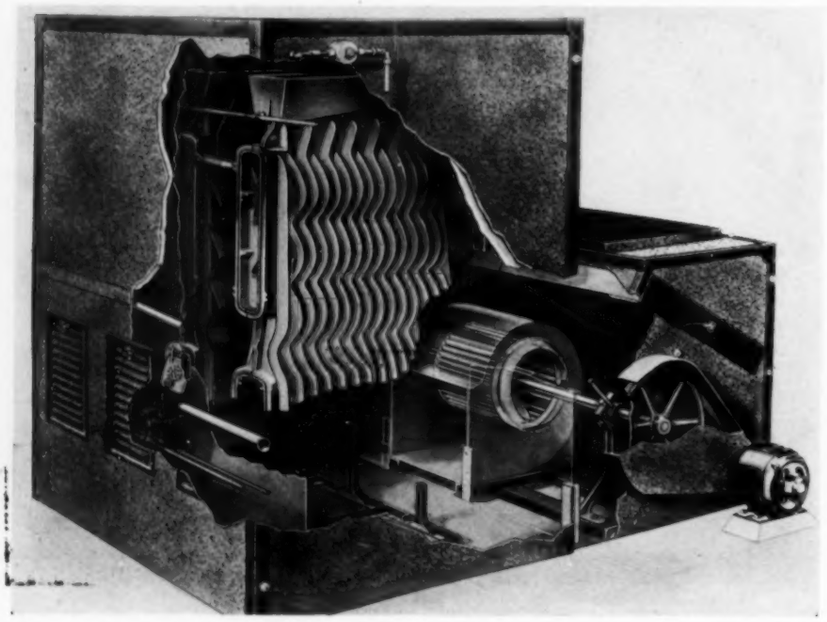

FIG. 5—AUTOMATIC FORCED WARM AIR UNIT

Estimating the Cost of Heating with Gas

A very important item, particularly where manufactured gas is the fuel, is the cost of operation. This may be determined by calculating the amount of heat loss from the home per degree-hour, then multiplying by the degree-hours in a normal heating season (degree-days* x 24). The amount of gas required to offset this seasonal heat loss is obtained by assuming 75 per cent operating efficiency for gas designed equipment and 67.5 per cent seasonal operating efficiency for conversion equipment. The calorific value of the gas may be obtained from the local gas company in each case.

The A. S. H. V. E. GUIDE 1931 expresses the foregoing relationship for a 75 per cent operating efficiency as follows:

$$G = \frac{110 \times R \times D}{H}$$

where—

G = Cubic feet of gas per season
R = Square feet of equivalent direct steam radiation (calculated)
D = Degree days per season
H = Gross calorific value of the gas (Btu per cubic foot)

The cubic feet of gas must, of course, be multiplied by the average price of the gas to obtain the fuel cost per season.

In considering the cost of heating with gas it is well to bear in mind that there will be considerable variation in the monthly gas bills throughout the

*Degree Days—A degree day may be said to be a day in which the average outside temperature is one degree less than the average inside temperature. The degree days for a heating season are obtained by subtracting the average outdoor temperature for the season from the average inside temperature and then multiplying this temperature difference by the number of days in the heating season. The degree days (based on an average inside temperature of 65 F) for a number of cities in the United States and Canada are given in THE GUIDE 1931.

year. The variation will be in proportion to the number of degree-days in the different months. Table 2 indicates the proportion of the total season's gas bill which will occur in each month of a normal heating season for Chicago. The amounts of the bills in the case of a $300.00 per year example also are shown. These variations in monthly fuel consumption are practically the same no matter what fuel is used, but they are perhaps more noticeable with gas because of the regularity of the meter reading and billing.

FIG. 6—CONVERSION GAS BURNER INSTALLED IN WARM AIR FURNACE

Needless to say, anything which reduces the amount of heat loss from a building such as insulating walls and roof, applying storm windows, keeping the room temperature as low as comfort will permit, etc., will produce a proportionate decrease in the gas consumption and is recommended for use.

Installation of Equipment

Gas-fired boilers for steam and hot water heating systems may be cross connected with boilers fired with other fuels, if so desired. In many instances cross connection is to be preferred for it gives the user a means of disposing of boxes, papers and other basement rubbish.

When cross connecting steam boilers, it usually is advisable to completely valve off both boilers, but with hot water systems the placing of gate valves in the return pipes leading to the coal boiler is sufficient in most cases to stop any circulation of heated water through the coal boiler.

In making gas-fired installations, it is important that any faults in the old heating systems be remedied. This is desirable for two reasons; *first,* users are wont to blame the new equipment or the fuel for faulty operation of the heating system; and *second,* some faults are often accentuated by the use of gas as a fuel and, therefore, become much more noticeable. Poor venting of the air from steam heating systems, for example, is more noticeable with gas because of the fact that the gas, when burning, usually is burning at its maximum rate and builds up steam pressure quickly. If the air vents are not functioning properly, the burner will be shut off by the pressure limit control due to air pressure rather than steam pressure.

Not infrequently, such changes may be made in a heating system that gas will be given credit for being an even better fuel than it deserves. For example, it is not unusual to find a warm air heating system with altogether inadequate cold air return piping—perhaps just one small sized cold air pipe having an opening to the out-of-doors. If, then, in making the gas-fired installation this cold air pipe to the outside is cut off and an adequate amount of recirculating cold air return piping is installed, the resulting improvement will make the user a strong booster for gas heating.

TABLE 2—RELATIVE GAS CONSUMPTION AND COST[a] IN CHICAGO FOR VARIOUS MONTHS OF HEATING SEASON

	Relative Gas Consumption Per Cent	Relative Cost
October	5.2	$15.60
November	12.0	36.00
December	18.1	54.30
January	20.6	61.80
February	17.5	52.50
March	14.8	44.40
April	8.7	26.10
May	3.1	9.30
Total	100.0	$300.00

[a] Based on $300.00 per year example.

Chimney Construction Is Important

Another matter of some importance is that of having an adequate and properly constructed chimney. Due to the relatively large amount of hydrogen in gas, the combustion products will contain a fairly high concentration of water vapor—15 to 20 per cent by volume for air-free combustion products. The presence of this water vapor gives the flue products a dew-point temperature of about 130 F or lower, depending upon the amount of excess air. The presence of this rather large amount of water vapor in the flue products often causes some condensation to take place when chimneys or boiler breechings are cold.

In some instances this condensation is quite excessive and at the same time slightly acidic in character. If this acid condensate is formed in an unlined brick chimney in which lime mortar has been used, it is quite probable that the lime will be leached out of the mortar and, of course, the latter will disintegrate. This type of construction is seldom encountered except in old buildings, as most municipal building codes now require tile lining and cement mortar for brick chimney construction.

In cases where a chimney has started to disintegrate, however, or where it is evident that the use of gas as a fuel is liable to cause disintegration, it usually is best to line the chimney with some corrosion-resisting material. The so-called 18-8 chromium nickel iron alloys are excel-

lent materials for this purpose and are commercially available in the larger cities. If a chimney has no offsets, the 24-gage alloy sheets can be formed into pipe and lowered into place from the top of the chimney with a minimum of labor expense. In making this lining the male end of the pipe length should be downward so that any condensate which forms will be kept inside the lining. A drain or sump should be provided at the base of the chimney in order to dispose of the condensate with a minimum of inconvenience.

Caring for the Installation

Almost all of the gas companies in this country are now more or less active in the promotion of the use of gas for house heating. Obviously the retaining of the present house heating load is fully as important as the

FIG. 7—GAS FIRED STEAM RADIATOR

acquiring of additional business. For this reason most of the gas companies service their house heating installations periodically to keep them in first class condition. These service calls are made annually or semi-annually as a matter of routine and at such other times as customers may request. Only a very nominal charge, if any, is made for this work.

In addition to the mechanical service given, most gas companies find it necessary to keep records of the degree-days and proportions of the seasonal fuel requirements which weather conditions cause each day. In this way it is a relatively simple matter to determine whether a customer's gas consumption for a given period is in accordance with the seasonal estimate as given by the gas company. This is done by comparing the degree days for the period in question to the degree days in a total normal season and noting whether the gas consumption is in similar proportion to the seasonal estimate.

Other Types of Equipment

In addition to the appliances already mentioned there are other types of equipment which are quite suitable for auxiliary or complete heating systems.

Gas-steam radiators (Fig. 7) and warm air circulating heaters (Fig. 8) are particularly well adapted for buildings and stores where stoves have been used or where there are no basements.

FIG. 8—GAS FIRED WARM AIR CIRCULATING HEATER

Unit Heaters

The recently-developed gas-fired industrial unit heater is rapidly coming to the front as an important appliance in the heating field. This type of heater may be suspended in the space which is to be heated and air is blown over the heating surfaces and into the space to be heated without ducts or steam or water piping. Just as with the other types of space heaters, provision should be made for carrying the combustion products from unit heaters to the outside unless there is no objection to having moist air indoors.

These heaters already have found wide application for use in stores, shops, factories, and in some localities in garages. Maximum economy of operation is obtained because the air is heated directly and the heat losing walls and ceiling are heated more or less indirectly. A tremendous advantage, of course, is that no floor or wall space needs to be sacrificed for the heating system where these unit heaters are installed and an adequately sized unit heater installation will heat up a cold store or shop very quickly.

The present state of the use of gas for house heating is the result of very few years of development and, no doubt, the future will see even greater developments due to the increased activity in this field. However, even the present perfection of the art indicates that gas can be advantageously applied to almost any problem of the heating industry due to its collateral advantages. In the localities served by natural gas, marked economies can be shown even when comparing bare fuel costs.

Relation of Standardization to Air Conditioning in the Printing Industry[1]

By W. H. Carrier,[2] Newark, N. J.
MEMBER

STANDARDIZATION as used in this paper refers to the general movement to elevate the printing industry from the status of a handicraft to that of a standardized manufacturing industry, the technique and processes of which are capable of so-called scientific management.

The specific technical advantages in printing plant operation which are to be gained from the installation of air-conditioning equipment are well known. Paper stretches and shrinks under varying conditions or relative humidity; rolls, plate mounting, inks and other materials used in the industry are affected by varying changes in temperature and humidity; and the installation of apparatus for controlling these variations will, or at any rate should, overcome a number of these difficulties.

Practically every advancement in the technique of the graphic arts, as well as other industries, has been in the direction of standardization of processes and material, or to the reduction of manufacturing materials and methods to a simplicity capable of accurate measurement and control. An effort has been made to eliminate the rule of thumb craftsmen who by virtue of years of experience and cut-and-try methods, can arrive at tolerable results with uncertain and unforeseen materials and methods, and to replace him with standardized methods and materials which give, in effect, their own control.

As technical control of process and material has grown more accurate, it has been observed that the effects of atmospheric conditions upon them have become more apparent. For example, as accuracy of machine manufacturing and the use of precision plates and machinery have become more common, the effect of varying moisture upon press packing has made itself more evident. As registering apparatus and step and repeat-printing-down machinery have become more widely used and more accurate, giving highly accurate registered forms, the stretch and shrinkage of stock working against this investment in expensive registering apparatus have been felt more acutely.

This is also true not only in the mechanical engineering aspects of the industry, but also in its industrial engineering aspects. The attempt to apply *scientific management* to the printing industry, the attempt to find the *one best way* and numerous attempts to raise production and decrease costs in the industry by scientific bonuses and wage incentive plans, have, to a very large extent, been snagged upon the rock of the wide and apparently hitherto unaccountable variations in production which have been encountered by those engineers working in this field. In short, until very recently there seems to have been what the early scientist called "a conspiracy of Nature" to prevent printing production being reduced to measurable standards. In fact, it is probable that a large majority of so-called practical men in the industry would still assert that the industry is inherently incapable of standardization.

Variable Factors

The author does not believe this to be the case. It is recognized that printing, a made-to-order business, has many congenital obstacles in this direction. Nevertheless, it appears that the immeasurable—or at any rate hitherto immeasurable—variables are being solved out of the problem and there seems to be no reason why they should not all eventually be reduced to workable limits. Of these variable factors which make the application of standards to the industry so difficult, it now appears that one of the first is *weather*. This leads more or less to the situation in which the average progressive printer finds himself today; that is to say, he recognizes that varying atmospheric conditions have a distinct influence upon his production, and that the installation of air-conditioning equipment has given favorable results in those plants which have installed it. He is, however, confronted as far as concerns him personally, with a double problem; *first*, how to determine the economic value of air conditioning to his own plant; and *second*, presuming that his findings show the desirability of installing such a system, what sort of system should he install.

In studying this problem with printers, just as the air-conditioning engineer is required to do in nearly every industry he encounters, the logical and scientific way to go about the question of the value of an air-conditioning system would be to analyze the time tickets, roller bills, ink bills, and other records of machine operation and material used during the course of a year, and make an estimate of the loss in production and spoilage of material resulting from uncontrolled atmospheric conditions. The difficulty with this method is that it seems to be impossible. To the author's knowledge, there is not an existing printing plant having time tickets which are sufficiently accurate to show the losses in production and stoppages of machinery or spoilages of work due to any particular cause, whether it be weather or anything else. There are, of course, specific items which could be taken from tickets, such as total time for re-registering forms or for re-making plates, but these are only a small part of the whole influence of weather. To the author's

[1] Abstracted from paper presented before the Second Conference of the Technical Experts in the Printing Industry, March 16-17, 1931, held in The Government Printing Office, Washington, D. C., and sponsored by the Printing Industries Division of the *American Society of Mechanical Engineers*.

[2] President, American Society of Heating and Ventilating Engineers.

knowledge, no time ticket has ever been designed or used which shows the three minutes a pressman will stop a press to reset a slightly swollen roller; the 20 or 30 impressions per hour that a feeder may lose due to slightly wavy stock or a slight amount of static; or the 5 or 10 minutes of make-ready time which may be required for resetting the guides where the sheets are stretched slightly but not enough to make necessary re-registering the form. These are the items, individually rather insignificant, which involve a distressingly large financial loss during the course of a year.

As already stated, it is practically impossible to segregate the individual items of loss caused by atmospheric variations. Nevertheless, it is possible to secure a fair approximation of their total from the showing made by their elimination in conditioned plants.

The following items of operation in the press room are affected by the weather:

1. Make-Ready.

a. This operation involves registering the form and in this connection it has been found that modern furniture and blocks are sufficiently influenced by humidity seriously to affect the operation time. It has been found, for example, that mounted plates with an average distortion from type high three times as great when stored in unconditioned areas as in conditioned. This results in increased underlaying and interlaying time. Registering the form also involves re-registering in cases when the stock has changed size between runs.

b. After registering the form, make-ready time includes setting the guides. This operation must be repeated if the stock has changed between runs.

c. Make-ready time also involves packing the cylinder, and if the humidity changes greatly during the course of the run, the packing may become soft and baggy and require changing.

d. The making of spot sheets is also to some extent affected by humidity as the distortion of the form and swollen packing may necessitate more patching.

e. Placing and setting of rollers also is included in make-ready time and if they are shrunk or swollen, soft or hard, due to weather changes, not only minutes, but hours of extra time will be consumed in the endeavor to secure the perfect rolling contact so necessary to a good job.

f. The setting of the fountain is also affected by atmospheric conditions insofar as the condition of the stock and rollers affects the quantity of color to be run.

g. Finally, the condition of the stock and small amounts of static may increase the amount of time required for setting the feeder.

Make-ready time is a chargeable but an unproductive operation. Each minute so expended is a minute taken from the production of the impressions for which the customer is paying. A minute less make-ready is a minute more of potential production. Thus it is proper to include savings in make-ready time with running time.

2. The effects of weather conditions upon *press running* may be tabulated as follows:

a. Curved or wavy edged stock due to uneven expansion in the pile may cut production by 50 or so impressions per hour on slightly bad stock, to 100 per cent on stock too bad to feed at all.

b. Very light stock may have to be fed by hand.

c. Static electricity, generated by friction in dry air, will slow production by from 5 per cent to 100 per cent.

d. Slip sheeting, necessitating slowing down of the press, extra crew, and extra bindery time for pulling slip sheets is largely caused by the static freezing the sheets together and by using excessive quantities of ink due to unsatisfactory conditions of stock, temperature conditions affecting the flow of the ink, and poor distribution due to swollen rollers.

e. The time for resetting swollen, shrunk or melted rollers is a considerable factor in reducing press production.

f. The drying of ink, which sometimes takes place too fast (crystallizing) and sometimes too slowly, is profoundly affected by atmospheric conditions, both directly as temperature and humidity conditions affect the ink itself, and indirectly as the conditions of stock and rollers affect the quantity of ink run and possible empirical changes in it made by the pressman. Until *weather conditions* are standardized there will remain possible only the most uncertain prediction as to how long it will take a given job to dry.

As stated before, it has been found impossible to segregate the cost of these individual delays. But in their total, it is possible to predict with some accuracy, by the examination of other plants, that their elimination will result in an increase of 8 per cent in press production, or to state it conversely, that the cost per 1,000 impressions (the unit cost) over the course of a year, should decrease 8 per cent. Similarly, it has been found from experience that a saving of 10 per cent may be secured in folding machine operation, and a substantial saving made in roller and ink bills. Indications also point to a decreased loss of time due to sickness on the part of the personnel.

However, in the lack of standards in the printing industry at present, each plant manager believes that there are special features about his own business which make it *different* from others and not to be judged by their experience. In such cases, therefore, it can only be suggested that each plant must set up its own standards, or at any rate, some datum from which production can be measured. Such a procedure if carefully done, will, it is believed, give a very close approximation of the probable economic worth of air-conditioning equipment, and at the same time, give the plant manager the opportunity of putting his finger on a number of other sore spots which may appear.

Characteristics Controlled by Air-Conditioning System

The control of atmospheric conditions involves controlling five separate characteristics of air:

1. Temperature
2. Humidity
3. Air Movement
4. Cleanliness
5. Ventilation

A complete air-conditioning system must control all these characteristics and insofar as it omits the control of any of them, to that extent it is an incomplete system. Each of these features has its individual importance to the printing industry.

Control of Temperature

The control of temperature, while perhaps not so obviously necessary as the control of humidity, is nevertheless of considerable importance to the printing industry. This is particularly true on the low side. If temperatures in a press room are allowed to drop below 75 F (the author believes 78 F) the "tack" of the ink is increased, the flow slowed, rollers become stiff and poor distribution results. This is especially noticeable over holidays and week-ends. If the temperature has been allowed to drop, it frequently takes several hours on Monday mornings before the large amount of metal in the machines can be heated up sufficiently to permit run-

ning. The mechanical circulation of warmed air appreciably reduces this warming-up period. An important aspect of air distribution and temperature control is the even distribution of heat so that one portion of the plant may be adequately heated without overheating other portions. The same applies in establishing uniform conditions of humidity in a given area.

The limitation of high temperatures in the general commercial plant is of less importance in its mechanical effect upon printing operations than the accurate control of humidity. However, care must be taken that the design of the system does not necessitate inhumanly high temperatures (above 90 F) in order to secure constant humidity where refrigeration is not used, and special consideration must be given to such portions of the plant as monotype caster rooms, stereotype and electrotype foundries, and photographic galleries where excessive amounts of heat are generated, to carry this heat away and to produce relatively comfortable working conditions.

In certain special departments, the control of maximum temperature is of importance. In the sensitizing and etching departments of rotogravure plants, temperatures should not be allowed to exceed 75 F, both from the sensitive nature of the gelatine films used and because the temperature of the etching bath, which follows the wet-bulb room temperature, is of the highest importance. The control of maximum temperatures is also indicated in photo-litho plate making departments.

Control of Humidity

The control of relative humidity, that is, its maintenance at a constant point, is of the greatest importance as already stated. This involves the addition of moisture to the air when it is deficient, and the reduction of the relative humidity when it becomes too high. This latter process may be accomplished, *first*, by true dehumidification, that is, the removal of the moisture from the air by chilling it below its dew point; or *second*, by heating it to the temperature at which its relative humidity is reduced to the required point. The first of these methods, while rather more expensive, gives control both of humidity and temperature, and permits lower humidities to be carried in summer. It would be indicated in such places as photo-litho plants where relative humidities of 50 per cent and control of maximum temperatures are desirable.

For the commercial letter-press plant, the maintenance of a fixed humidity by automatically shifting the dry-bulb temperature is economical and entirely practical. While it is true that this method of control at times of high outside wet-bulb temperature leads to somewhat uncomfortable working conditions, its first cost is so appreciably below that of a complete dehumidifying system as to warrant careful consideration. And inasmuch as a fixed relative humidity is the outstanding requirement of the letter-press plant, such a system will go far toward correcting the difficulties outlined.

In many cases it has been found possible to accomplish dehumidification without the installation of refrigerating equipment, by the use of an already available supply of well water, either from a well or, in certain localities, by using the city water supply. The possibilities of such a source of cold water being available should be investigated on each individual job. In general, quantities of water of 200 gpm or more at temperatures not much over 55 F will be required.

Control of Air Movement

The question of air movement, or the distribution of conditioned air throughout the plant, is one of rather more vital interest in air conditioning for the printing industry than in some other types of industrial applications, and it is one that is sometimes apt to be neglected, although it is axiomatic that no air-conditioning system is better than its distribution. In a printing plant, care must be taken to secure uniformity of conditions throughout the plant, to distribute the air in accordance with the heat load and to use air velocities and locate duct outlets in such a position that drafts are avoided both where stock might be distributed or personnel made uncomfortable. There are a number of special departments such as foundries and machine composing rooms where special types of distribution must be used in connection with exhaust systems to handle the large amounts of air required, and others such as large web presses which require special treatment in order to avoid *dead spots*.

Air Cleanliness

Cleanliness of the air circulated is also of importance in printing plant work where floating dust settling upon forms, rollers, wet plates and films is the cause of distressing stoppages and spoiled work. All outside air should be thoroughly cleaned before being brought into the plant and if there are unusual amounts of impurities outside, such as soot, special cleaning procedures must be used. Similarly, the dirt produced inside the plant must be removed from the air and where such impurities as bronze, graphite, and the carbon dust of photographic arcs are encountered, provision must be made to prevent their return through the distributing system. A microscopic and bacteriological analysis of the impurities washed from the air of a printing plant will reveal the importance of this factor, both from an operating and from a hygienic standpoint.

Ventilation

Finally, a complete and properly designed air-conditioning system should provide for ventilation, that is, it should positively bring into the plant sufficient outside air to make up for that vitiated by people, gas burners and other factors, to make up for such air as is exhausted to carry away fumes, and to maintain a slight positive pressure in the building.

Conclusions

These are the qualifications of a complete air-conditioning system. An individual printing plant may need all of them or only some of them. Some of them may prove to be technically desirable, but economically out of reach. All possible permutations and combinations of these five characteristics may be and are being installed in the printing industry. A system may control humidity but not temperature; it may heat but not cool; it may cool but not heat; or it may ventilate and do nothing more. To determine the type of system to be used and how far it should go is the duty of a competent air-conditioning engineer working in conjunction with the printing plant manager, and thereby balancing the requirements of the system against its economic value.

Proposed Code for Testing Steam Heating Boilers Burning Oil Fuel[1]

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

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I. INTRODUCTION

1. The purpose of the Code for Testing Steam Heating Boilers Burning Oil Fuel is to provide a standard method for conducting and reporting tests to determine heat efficiency and performance characteristics. The Code recognizes that tests of oil burners and boilers may be made under different conditions for different purposes, and with complete or limited facilities for conducting the tests. It is designed to cover the determination of a complete heat balance; if a less complete test is required to satisfy the objectives of the test, observations not required may be omitted. It should be appreciated that in all cases to which this code applies there are two devices (that is, boiler and oil burner) involved in the test. Both devices influence the results obtained. Two different oil burners placed successively in the same boiler may not produce identical results. To view the results as if they pertained only to the boiler, would be an incorrect viewpoint.

2. Standard Form. Table 1, Standard Form, Oil Fuels, is arranged for recording the full data called for by this Code.

3. Short-Test Form. Table 2, Short-Test Form, Oil Fuels, is for tests in which a complete heat balance is not desired. The following determinations are not required:

(a) Ultimate analysis of fuel
(b) Complete flue gas analysis
(c) Furnace volume *A* and *B*
(d) Unit combustion rate

4. Continuous and Intermittent Tests. Two general types of tests are recognized which may use either the Standard or Short-Test Form. These will be designated as Continuous and Intermittent. A continuous test may be defined as one where fuel is burned throughout the duration of the test at a constant rate. An Intermittent test is one where the fuel may not be burning at all times during the test or, if burning continuously, the rate of burning varies. These methods are treated in detail in Sections VII and VIII of the Code.

II. DEFINITIONS

5. Furnace Volume. There are two furnace volumes to be considered, which will be designated as furnace *A* and furnace *B*.

6. Furnace A is the total volume enclosed by the boiler and boiler foundation which may be used as combustion space. This space is that enclosed by the floor, side walls, and/or water legs, up to the crown sheet or equivalent which shall be a plane tangent to the bottom of the lowest row of tubes or other water backed surfaces. A bridgewall shall constitute a side wall. The average width, length and height of the furnace shall be indicated on a dimensioned sketch.

7. Furnace B is the space left in furnace *A* after the oil burner has been installed. The lower bounding surface will generally be the hearth of the furnace or equivalent, the side bounding surface the same as furnace *A*, except as modified by brick work on the sides and ends, and the upper bounding surface the same as furnace *A*. Again the average dimensions shall be recorded on a sketch.

8. Combustion Rate. This shall be recorded as the number of gallons, pounds and Btu per hour supplied to the burner.

9. Unit Combustion Rate. This shall be recorded as the number of gallons, pounds and Btu per hour per cubic foot of furnace *B* supplied to the burner.

10. Boiler Output. The quantity of heat available at the boiler nozzle with the boiler normally insulated.

11. Overall Efficiency. The percentage of the heat in the oil fuel fired which is delivered at the boiler nozzle when the boiler is normally insulated.

III. SET-UP OF OIL BURNER AND BOILER TO BE TESTED

12. The Oil Burner. If the oil burner is set up for the purpose of commercial testing, it shall be installed according to manufacturer's directions.

Experimental work is limited in no manner except that the manner of installation shall be clearly described.

13. The Boiler. If the boiler is set up for the purpose of testing, it shall be assembled according to manufacturer's directions.

14. Boilers already installed shall be arranged to comply with the following conditions as nearly as possible, or as shall be agreed to by all interested parties.

15. Boiler Covering. The boiler should be covered with such heat insulation as is recommended by the manufacturer; if tested uninsulated or partly insulated an allowance shall be made for that portion of the heat lost from the bare iron steam and water surfaces which might have been saved by covering; the allowance shall be computed from the formula given with the tables of this Code.

16. Steam Outlet Piping. All steam outlet pipes from the boiler shall always be well covered, up to and including the steam separator.

17. The vertical outlets from the boiler leading up to the separator shall be in number, arrangement and size according to manufacturer's directions and shall rise vertically from the boiler nozzle as high as possible but not more than 30 in. before entering the steam separator.

18. The steam piping leading from the separator shall have a slope so that water condensed in it will drain away from the separator. The drain pipe from the steam separator shall include a *U*-leg sufficiently long to prevent the steam blowing out, and with a short inverted *U*-leg at the outlet, so that the drip may be caught in a container. Re-evaporation of water drained from the separator shall be prevented by use of a suitable cover on the container.

19. The steam valve on the boiler steam outlet piping shall be placed beyond the steam separator.

20. Feed Water Piping. The feed water pipe should connect to the boiler where the returns would normally come. The temperature of the feed water shall be read from a thermometer inserted in a cup projecting well into the feed line near the boiler and filled with a heavy oil or mercury. A valve shall be placed on each side of the above-mentioned cup. The valve between the cup and boiler shall serve as

[1] This code was prepared by the Technical Advisory Committee on Oil Burning Devices (1930-1931) consisting of L. E. Seeley, *Chairman*, P. E. Fansler, R. V. Frost, H. R. Linn, J. H. McIlvaine and H. F. Tapp.

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a shut-off valve. The valve between the cup and feed water supply shall be used as a regulating valve only. This valve may be an automatic one for maintaining a uniform water level in the boiler.

21. All boiler-water connections, including blow-off pipes, must be exposed to view, so that leakage may be observed and either stopped or measured. It is desirable to have a steady rate of feed so that feed water temperature readings will be accurate and none will have to be omitted.

22. Water Gage Marking. The water gage shall have a mark to indicate the water level recommended by the manufacturer.

23. Smokehood Connections. The boiler shall be connected with a short, direct smoke-pipe to a chimney flue of suitable size, height and construction to give proper draft. All joints shall be thoroughly sealed and maintained so during the tests.

24. Insulation. The smokehood and the smoke flue shall be insulated with not less than 1-in. thickness of insulation; the smoke-flue insulation shall extend at least one equivalent flue diameter beyond the point where the flue-gas temperature is measured.

25. The choke damper, if incorporated in the boiler, shall be put in place, opened wide and kept so during all tests. A damper shall be placed in the smoke pipe between the chimney and the point where flue-gas measurements are made. This shall be called the regulating damper. A check damper, either manual or automatic, may be placed between this damper and the chimney if desired.

26. Chimney. This code allows that the draft may be produced by a chimney or by a fan or other arrangement for providing induced draft; there shall, however, be a suitable damper or by-pass in the test flue or chimney that will permit of the draft at the regulating stack damper being reduced to a little above that required for the output of the test which is being made.

27. Cleaning of Boiler. The water spaces of the boiler shall be thoroughly boiled out with a cleansing solution, then thoroughly rinsed with clean water.

28. Soot and Dust. The heating surface, furnace, flues and chimney shall be clean and free from soot and dust at the beginning of the test.

IV. INSTRUMENTS AND MEASURING APPARATUS

29. Steam Output. The weight of water evaporated may be determined either by condensing the steam and weighing the condensate, designated as Method *A*, or by weighing the water fed to the boiler, designated as Method *B*.

30. Method A. Water shall be fed to the boiler without being weighed. The steam after passing through the separator shall be led to a condenser through a connecting steam pipe sloping toward the condenser. The condensate shall be caught in suitable tanks and weighed. The condenser shall be the closed type, preferably with outside joints, and of sufficient capacity that the temperature of the condensate shall not exceed 150 F. Before each test it shall be tested for freedom from leakage by putting it under full water pressure.

31. Method B. The quantity of water fed to the boiler shall be determined in weighing or measuring in a calibrated tank. The most convenient weighing arrangement depends on the size of the boiler, but it shall be such that the weight fed can be determined at any instant. The use of tanks calibrated for the weight of water they hold at the temperature of the feed is permissible. The water may be fed to the boiler by gravity, air pressure or feed pumps; there shall be no leakage between the measuring tanks and the boiler.

32. Weighing Scales. Accurate scales of suitable size shall be provided for weighing separator water, feed water, and fuel. If the oil tank is mounted on scale it shall be connected to the burner by means of flexible oil-tight tubing. Water and oil may be volumetrically measured by means of calibrated tanks.

33. Draft. Two draft gages shall be provided and so arranged as to determine the pressure difference between the room atmosphere and the furnace and the smokehood. Draft measurements shall be made with draft gages reading to 0.01 in. Draft gages shall be checked for zero reading each hour.

34. The smokehood draft shall be measured at least one pipe diameter before the regulating stack damper. The connection into the stack flue shall have its end square and shall be set at right angles to the flow of the gases. A ½-in. pipe is a convenient size.

35. Steam Separator. The steam separator shall have sufficient volume to catch slugs of water and to prevent their passing into the steam lines; it shall also efficiently separate entrained water from steam carrying it.

36. Temperature Measurement. Accurately calibrated instruments shall be provided for all temperature measurements. A mercury thermometer is preferable for measuring feed water temperature. It is recommended that thermocouples, in preference to other types of thermometers, be used to measure the flue-gas temperatures. The temperature shall be measured in the smoke pipe not less than one nor more than two pipe diameters beyond the smoke-pipe collar. The thermo-junction or bulb of the thermometer shall be placed as shown on the sketch. The instrument used with the couple should be sensitive to at least 5 deg Fahrenheit and have a range up to 1200 F.

37. Gas Analysis. The sample for gas analysis shall be taken from the smoke pipe at the point at which the temperature is measured in such a manner as to give a fair average sample of the gas stream. An Orsat or equivalent gas analyzer shall be used. An open end ⅛-in. pipe reaching one-quarter way across the flue pipe is usually satisfactory, but the probable mixing of the gases should be considered and the open end so placed as to be in the average gas stream. For gas temperatures of over 750 F the portion of the collecting pipe extending into the flue should be clay or silica. As an average value for the test period is desired, the correct and simplest method is to collect samples of the flue gas at a constant rate into a one-gallon bottle approximately, and to take the samples for analysis from these bottles. Each of such samples shall be collected for the same length of time and their analyses averaged. If recording gas analyzing instruments are provided, they shall be checked every hour with the Orsat or other manual apparatus.

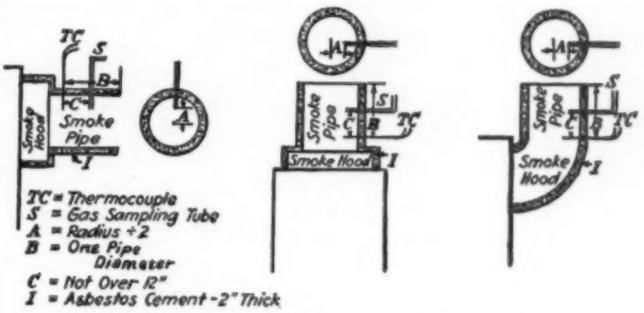


FIG. 1—LOCATION OF GAS TEMPERATURE THERMOCOUPLE AND GAS SAMPLING TUBE

38. Smoke Readings. Smoke readings if desired shall be made by the Ringelmann Chart Method.

39. Pressure Readings. A calibrated steam gage or a mercury column shall be used for determining the steam pressure.

V. FUEL SAMPLING

40. A fair sample of the oil shall be obtained (not less than two (2) quarts). This may be done by taking some oil from the small tank especially used for testing or an occasional sample from the oil supply line to the burner. The sample should be placed in a tight vessel, marked with test number and stored in a cool place.

41. Fuel analysis. The fuel shall be analyzed according to the method of test specified by the *American Society for Testing Materials.*

Note: For the Standard form the ultimate analysis must be obtained in addition to the usual findings. The short form requires only a heat value determination.

42. A calculated heat value may be used, especially in field work, with reasonable accuracy for that type of work. It is not recommended for laboratory tests (see item 17, Table 2).

VI. DURATION OF TESTS

43. The duration of tests shall be based on the firing of the minimum quantity of fuel oil to make the quantitative errors comparable for all tests.

44. For the continuous test the total quantity of oil fuel burned shall be at least two pounds of oil per cubic feet of Furnace *B* (see par. 5) and under no condition shall the test be less than two hours duration.

45. For the intermittent test the total quantity of oil fuel burned shall be at least three pounds of oil per cubic foot of Furnace *B* (see par. 5).

VII. STARTING AND STOPPING CONTINUOUS TESTS

46. Operating Conditions. After the burner has been started and the combustion rate and draft have been adjusted, all operating conditions shall have remained constant for one-half hour before the test is started.

47. Start of test. At the start of the test the time, fuel, feed water and gage glass level shall be quickly measured and recorded. A pail shall be placed under the separator outlet.

48. End of test. At the end of the test the gage glass level should be at exactly the same point existing at the beginning of the test and the time, fuel and feed water shall be quickly measured and recorded. The separator water in the pail shall be weighed and recorded.

VIII. STARTING AND STOPPING OF INTERMITTENT TESTS

49. Measurements and procedure. In general the same measurements and procedure must be followed in these tests as outlined in Section VII. Due to the fact that intermittent operation includes a heating and cooling of the boiler, firebrick and so forth, it is absolutely necessary to be sure that the same conditions exist at both the beginning and end of the test.

50. The duration of the *on* or burning period of the test shall be such that conditions have become reasonably stabilized before going to the *off* or non-burning or possible *low-burning* period of the test. Flue gas temperature will show this stabilized condition quite well if succeeding readings show or indicate but small changes. For small boilers thirty minutes seems long enough. For large boilers longer periods might be necessary.

51. These tests shall be started and stopped at the end of an *on* period of sufficient duration as explained in par. 50. For any one test all the *off* periods shall be equal to each other in duration. The test readings except time and draft may be omitted during the *off* period except in cases where fuel is burning. To get correct averages when operating on the *low-burning* period it is necessary to obtain weighted averages of the flue-gas temperature and analysis readings according to the respective rates of fuel burning. This will give the required accuracy on the heat balance calculations called for in the Standard test form.

IX. METHOD OF CONDUCTING TEST

52. The steam pressure shall be maintained at 2 lb unless the purpose of the test requires operation at some other definite pressure. The water level in the boiler shall be maintained constant during the test.

53. Water fed or condensed. The records of water fed or condensed shall be made as required by the measuring system. It is desirable to measure the water fed or condensed each half hour to check the rate of steaming.

54. Observations of drafts, pressures and temperatures shall be made regularly during the test at least every 15 min. Separator water shall be weighed every hour.

55. Flue gas analyses shall preferably be made on samples collected for periods not exceeding 30 min.

56. Smoke readings when made shall be recorded at least every 30 seconds over a period of time sufficient to show the performance under all typical conditions. See Section IV, Par. 38.

X. PERFORMANCE CHARTS

57. If four or more continuous tests are run at different combustion rates a performance chart may be made. Against output expressed in thousands of Btu and square feet of steam radiation, the following items may be plotted; overall efficiency, flue temperature, combustion rate, furnace draft, boiler draft, unit combustion rate and CO_2.

58. If four or more intermittent tests are run at different *off* periods a performance chart may be drawn plotting overall efficiency against output expressed in thousand Btu and square feet of equivalent radiation. (E. D. R.)

STANDARD FORM

TABLE 1. DATA AND RESULTS OF TEST—LIQUID FUELS

General Information

1. Number of test
2. Date of test
3. Test conducted by
4. Type of test: continuous ____ intermittent ____
5. Make and catalogue designation of burner
6. Type of burner
7. Kind of ignition
8. Make and catalogue designation of boiler
9. Type of boiler
10. Description of boiler covering
11. Heating surface of boiler ____ sq ft
12. Furnace volume *A* ____ cu ft
13. Furnace volume *B* ____ cu ft
14. Weight of water in boiler to normal water line ____ lb
15. Duration of test ____ hours
16. Power consumed by oil burner ____ watts
17. Gas consumed by gas pilot ____ cu ft
18. Oil setting (valve position, oil pressure, nozzle, etc.)
19. Air setting (number of fan and adjustment, area of air opening, air pressure, etc.)
20. Description of flame (color, shape, condition, etc.)
21. Barometer reading ____ in. mercury

Fuel

22. Kind (Commercial Standard Grade) Number
23. Gravity ____ °A.P.I.
24. *Flash point ____ F
25. *Distillation Test (*a*) 10% at ____ F
    (*b*) 90% at ____ F
    (*c*) E.P. at ____ F
26. *Water and sediment ____ per cent
27. **Viscosity ____ seconds ____ method at ____ F

*According to Commercial Standard Specifications.
**Saybolt Universal at 100 F for No. 3 and No. 4 oil
Saybolt Furol at 122 F for No. 5 and No. 6 oil

28. Ultimate analysis:
    (*a*) Hydrogen ____ per cent of total weight
    (*b*) Carbon ____ per cent of total weight
    (*c*) Nitrogen ____ per cent of total weight
    (*d*) Oxygen ____ per cent of total weight
    (*e*) Sulphur ____ per cent of total weight
29. (*a*) Higher Heating value per pound as fired ____ Btu
    (*b*) Higher Heating value per pound moisture free ____ Btu
30. Total fuel fired during test ____ lb
31. Temperature of oil as fired ____ F

Draft

32. Draft in furnace ____ in. of water
33. Draft at boiler outlet ____ in. of water

Flue Gas

34. Carbon Dioxide (CO_2) ____ per cent volume
35. Oxygen (O_2) ____ per cent volume
36. Carbon Monoxide (CO) ____ per cent volume
37. Nitrogen (N_2) by difference ____ per cent volume
38. Temperature of flue gases leaving boiler ____ F
39. Temperature of air ____ F
40. Dry flue gas per pound of fuel, as fired ____ lb
41. Air supplied per pound of fuel, as fired (actual) ____ lb
42. Theoretical air required per pound of fuel as fired ____ lb
43. Excess air ____ per cent

Steam and Feed Water

44. Steam pressure by gage, boiler ____ lb per sq. in.
44a. Absolute steam pressure ____ lb per sq. in.
45. Temperature of feed water entering boiler ____ F
46. Total weight of water fed to boiler ____ lb
47. Total weight of water from separator ____ lb
48. Percentage of moisture in steam ____ per cent
49. Total water evaporated ____ lb
50. Factor of evaporation ____

Hourly Rates

51. Combustion rate ____ lb per hour
52. Combustion rate ____ gal per hour
53. Combustion rate ____ 1000 Btu per hour
54. Unit Combustion rate ____ lb per cu ft of furnace *B* per hour
55. Unit combustion rate ____ gal per cu ft of furnace *B* per hour
56. Unit combustion rate ____ 1000 Btu per cu. ft. of furnace *B* per hour
57. Actual water evaporated per hour ____ lb per hour
58. Correction for uncovered boiler ____ lb per hour
59. Total equivalent evaporation ____ lb per hour
60. Heat absorbed per square foot of boiler heating surface per hour ____ Btu per square foot per hour

Output

61. Output in 1000 Btu per hour ____ Btu
62. Output in square feet of steam radiation ____ sq ft
63. Actual evaporation per pound of fuel, as fired ____ lb
64. Equivalent evaporation per pound of fuel, as fired ____ lb

Heat Balance

65. Heat transferred to boiler, (overall efficiency of boiler, burner and furnace) ____ per cent Btu
66. Heat carried away by steam in flue gases ____ per cent Btu
67. Heat carried away by dry flue gases ____ per cent Btu
68. Heat loss due to unconsumed carbon monoxide ____ per cent Btu
69. Heat loss due to unconsumed hydrogen, hydrocarbons, radiation and unaccounted for miscellaneous items ____ per cent Btu

CALCULATIONS FOR TABLE 1

Explanation of Symbols

Wherever CO_2, O_2, and N_2 are used they are percentages by volume of these constituents in the gases of combustion.

H = Total heat (in Btu per pound of dry saturated steam at the boiler outlet pressure.)

h = Total heat (Btu per pound) in feed water at boiler inlet.

L = Latent heat (in Btu per pound) of steam at the boiler outlet pressure.

Formulae and Notes

$$\text{Item 40} = \frac{700 + 4\,CO_2 + O_2}{3\,(CO_2 + CO)} \times \text{Item 28 } (b)$$

$$\text{Item 41} = \text{Item 40} + \frac{9 \times \text{Item 28 } (a)}{100} - 1$$

$$\text{Item 42} = 34.56\left[\frac{\text{(Item 28 } (b)}{3} + \left(\text{Item 28 } (a) - \frac{\text{Item 28 } (d)}{8}\right) + \frac{\text{Item 28 } (e)}{8}\right]$$

$$\text{Item 43} = \frac{\text{Item 41} - \text{Item 42}}{\text{Item 42}} \times 100$$

Item 44*a* = (Barometric Pressure in Inches of Mercury × 0.491) + Item 44

Item 46 = (When condenser is used) weight of water from condenser + Item 47

$$\text{Item 48} = \frac{\text{Item 47}}{\text{Item 46}} \times 100$$

Item 49 = Item 46 − Item 47

$$\text{Item 50} = \frac{H - L \times \dfrac{\text{Item 48} - h}{100}}{971.7}$$

$$\text{Item 51} = \frac{\text{Item 30}}{\text{Item 15}}$$

$$\text{Item 52} = \frac{\text{Item 30} \times (131.5 + \text{A.P.I. gravity})}{\text{Item 15} \times 1180}$$

$$\text{Item 53} = \frac{\text{Item 30} \times \text{Item 29 } (a)}{\text{Item 15} \times 1000}$$

$$\text{Item 54} = \frac{\text{Item 51}}{\text{Item 13}} \qquad \text{Item 55} = \frac{\text{Item 52}}{\text{Item 13}}$$

$$\text{Item 56} = \frac{\text{Item 53}}{\text{Item 13}} \qquad \text{Item 57} = \frac{\text{Item 49}}{\text{Item 15}}$$

$$\text{Item 58} = \frac{1.8}{H - h}\,(T_s - \text{Item 39})\,A_s \text{ where}$$

T_s = temperature of steam at the boiler pressure: A_s is the allowed projected area of uncovered metal steam-heated surface. This item shall not be allowed on a commercial acceptance test.

Item 59 = (Item 57 × Item 50) + Item 58

$$\text{Item 61} = \frac{(\text{Item 59} \times 971.7)}{1000}$$

$$\text{Item 62} = \text{Item 61} \times \frac{971.17}{240}$$

$$\text{Item 63} = \frac{\text{Item 49}}{\text{Item 30}}$$

$$\text{Item 64} = \frac{\text{Item 59} \times \text{Item 15}}{\text{Item 30}}$$

$$\text{Item 65} = \frac{\text{Item 64} \times 971.7 \times 100}{\text{Item 29 } (a)}$$

$$\text{Item 66} = \frac{9 \times (1089 + 0.46 \times \text{Item 38} - \text{Item 39}) \times \text{Item 28}(a) \times 100}{\text{Item 29 } (a)}$$

$$\text{Item 67} = \frac{\text{Item 40} \times 0.24\ (\text{Item 38} - \text{Item 39}) \times 100}{\text{Item 29 } (a)}$$

$$\text{Item 68} = \frac{\dfrac{CO}{CO_2 + CO} \times \text{Item 28 } (b) \times 10{,}150 \times 100}{\text{Item 29 } (a)}$$

$$\text{Item 69} = 100 - (\text{Item 65} + \text{Item 66} + \text{Item 67} + \text{Item 68}$$

SHORT TEST FORM

TABLE 2. DATA AND RESULTS OF TEST—LIQUID FUELS

General Information

1. Number of test
2. Date of test
3. Test conducted by
4. Type of test: continuous ..... intermittent
5. Make and catalogue designation of burner
6. Type of burner
7. Kind of ignition
8. Make and catalogue designation of boiler
9. Type of boiler
10. Description of boiler covering
11. Duration of test ..... hours
12. Oil setting (valve position, oil pressure, nozzle, etc.)
13. Air setting (Number of fan adjustment, area of air opening, air pressure, etc.)
14. Description of flame (color, shape, condition, etc.)

Fuel

15. Kind (Commercial Standard Grade) Number
16. Gravity ..... °A.P.I.
17. Higher heating value per pound as fired (calculated) (calorimeter) ..... Btu
18. Total fuel fired during test ..... lb

Draft

19. Draft in furnace ..... in. water
20. Draft at boiler outlet ..... in. water

Flue Gas

21. Carbon Dioxide (CO_2) ..... per cent volume
22. Oxygen (O_2) ..... per cent volume
23. Carbon Monoxide (CO) ..... per cent volume
24. Temperature of flue gases leaving boiler ..... F

Steam and Feed Water

25. Steam pressure by gage boiler ..... pounds per square inch
25a. Absolute steam pressure ..... pounds per square inch
26. Temperature of feed water entering boiler ..... F
27. Total weight of water fed to boiler ..... lb
28. Total weight of water from separator ..... lb
29. Per cent of moisture in steam ..... per cent
30. Total water evaporated ..... lb
31. Factor of evaporation ..... lb

Hourly Rates

32. Combustion rate ..... lb per hour
33. Combustion rate ..... gal per hour
34. Actual water evaporated ..... lb per hour
35. Correction for uncovered boiler ..... lb per hour
36. Total equivalent evaporation ..... lb per hour

Output

37. Output in 1000 Btu per hour ..... Btu
38. Output in square feet of steam radiation ..... sq ft
39. Actual evaporation per pound of fuel as fired ..... lb
40. Equivalent evaporation per pound of fuel as fired ..... lb
41. Heat transferred to boiler (overall efficiency of boiler and furnace) ..... per cent Btu

CALCULATIONS FOR TABLE 2

Explanation of Symbols

H = Total heat (in Btu per pound) of dry saturated steam at the boiler outlet pressure.

h = Total heat (in Btu per pound) in feed water at boiler inlet.

L = Latent heat (in Btu per pound) of steam at boiler outlet pressure.

Formulae and Notes

Item 17 = Calculated heat value = 18650 + 40 (°A.P.I. − 10)

Item 25a = (Barometric Pressure Inches of Mercury × 0.49) + Item 25

Item 27 = (When condenser is used) weight of water from condenser + Item 28

$$\text{Item 29} = \frac{\text{Item 28}}{\text{Item 27}} \times 100 \qquad \text{Item 30} = \text{Item 27} - \text{Item 28}$$

$$\text{Item 31} = \frac{H - \dfrac{L \times \text{Item 29}}{100} - h}{971.7} \qquad \text{Item 32} = \frac{\text{Item 18}}{\text{Item 11}}$$

$$\text{Item 33} = \frac{\text{Item 18} \times (131.5 + \text{A.P.I. gravity})}{\text{Item 11} \times 1180}$$

$$\text{Item 34} = \frac{\text{Item 30}}{\text{Item 11}}$$

Item 35 = $\dfrac{1.8}{H - h}(T_s - T_a) \times A_s$ where T_s = temperature of steam at the boiler pressure; T_a = temperature of air; A_s is the allowed projected area of uncovered metal steam-heated surface. This item shall not be allowed on a commercial acceptance test.

Item 36 = (Item 34 × Item 31) + Item 35

$$\text{Item 37} = \frac{\text{Item 36} \times 971.7}{1000}$$

$$\text{Item 38} = \text{Item 37} \times \frac{971.7}{240}$$

$$\text{Item 39} = \frac{\text{Item 30}}{\text{Item 18}} \qquad \text{Item 40} = \frac{\text{Item 36} \times \text{Item 11}}{\text{Item 18}}$$

$$\text{Item 41} = \frac{\text{Item 40} \times 971.7 \times 100}{\text{Item 17}}$$

Officers and Council Members

W. H. CARRIER
Newark, N. J.
President

F. B. ROWLEY
Minneapolis, Minn.
First Vice-President

W. T. JONES
Boston, Mass.
Second Vice-President

F. D. MENSING
Philadelphia, Pa.
Treasurer

E. K. CAMPBELL
Kansas City, Mo.

E. O. EASTWOOD
Seattle, Wash.

Members of the Council for Three Years

ROSWELL FARNHAM
Buffalo, N. Y.

E. HOLT GURNEY
Toronto, Ont.

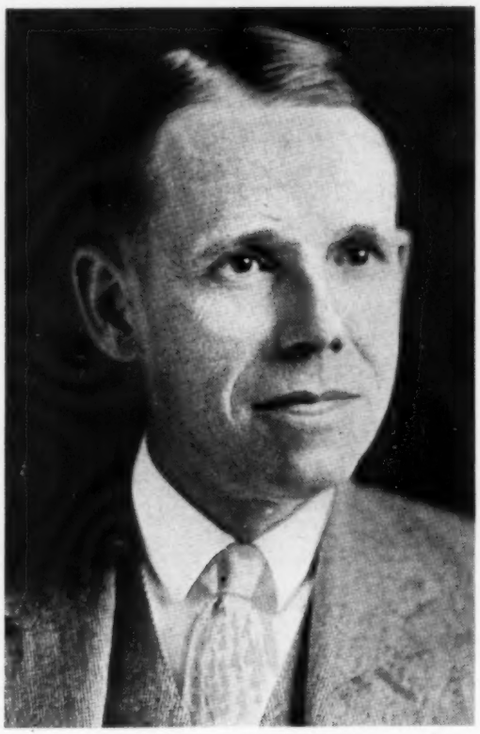
D. S. BOYDEN
Boston, Mass.

R. H. CARPENTER
New York, N. Y.

Members of the Council for Two Years

J. D. CASSELL
Philadelphia, Pa.

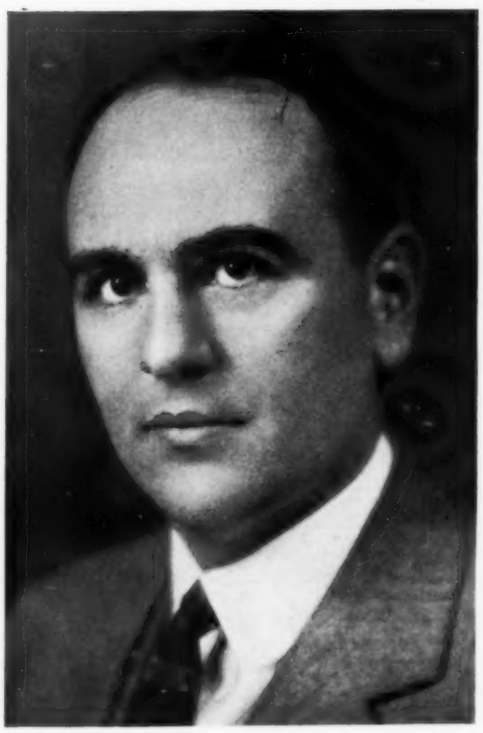
JOHN HOWATT
Chicago, Ill.



E. B. LANGENBERG
St. Louis, Mo.

G. L. LARSON
Madison, Wis.

Members of the Council for One Year



F. C. MCINTOSH
Pittsburgh, Pa.

W. A. ROWE
Detroit, Mich.

L. A. HARDING
Buffalo, N. Y.
Chairman Advisory Council

NEW OCEAN HOUSE

A. S. H. V. E. Ahoy!

Swampscott

June 22-25, 1931

SWAMPSCOTT, Mass., is the place of the Semi-Annual Meeting 1931, and Society members will gather at the New Ocean House, June 22 to 25, where they will be the guests of the Massachusetts Chapter of the A. S. H. V. E.

The General Chairman of Arrangements is D. S. Boyden, Boston, and W. T. Jones is Vice-Chairman. Nine other committees will carry out the program as follows: Reception and Registration, J. S. Webb, *Chairman;* Hotel and Meetings, Alfred Kellogg, *Chairman;* Finance, W. T. Jones, *Chairman;* Ladies' Entertainment, Mrs. E. A. Dussosoit, *Chairman;* Sports, E. A. Dussosoit, *Chairman;* Publicity, Leslie Clough, *Chairman;* Entertainment, J. W. Brinton, *Chairman;* Golf, J. F. Tuttle, *Chairman;* and Transportation, T. F. McCoy, *Chairman.*

The registration booth will be set up in the south end of the main lobby near the entrance to the ball room where all Technical Sessions will be held.

The entire day, Monday, June 22, will be reserved for Committee and Council meetings, and the first social event will be an informal reception and dance at 8:30 that evening.

The Technical Sessions will be held on each of the following three days from 9:30 a. m. to 12:30 p. m. after which members will have the opportunity to play golf, participate in other sports or do anything else that may suit their fancy.

Among the technical papers which have been offered are: Measurement of the Flow of Air Through Registers and Grilles, by L. E. Davies; Conversion Tables for Steam Unit Heaters Based on the Constant Volume Law, by L. S. O'Bannon and J. W. May; Use of Gas for House Heating, by H. B. Johns.

In addition to the various technical papers the special and technical committees of the Society will have reports to make on the work that has been done since the Annual Meeting.

In the near future members will receive a special invitation from the Massachusetts Chapter to come to Swampscott in June, and they will find in their mail a folder describing the hotel, historical places in New England, transportation and other important information.

Special plans have been made to entertain the ladies, and they will be afforded a splendid opportunity to visit historic New England during some of the trips which are in prospect.

Swampscott is located a short distance from Boston, and is one of the show places of Massachusetts' north shore. The Hotel headquarters are right on the ocean front, with a broad sandy beach for the exclusive use of the guests.

There is still evidence in Swampscott of its role as a typical old time fishing village, and the surrounding country has much of historic interest. Aside from the beautiful summer residences

FRONT VIEW, NEW OCEAN HOUSE

THE BEACH AND ROCKS IN FRONT OF NEW OCEAN HOUSE

and the fishing colony, one of the most interesting buildings in Swampscott is Olde Humphrey House, the oldest house in New England, which was built prior to 1637. White Court, the summer home of Ex-President Calvin Coolidge, is situated on Little's Point, within five minutes walk of the hotel.

Salem, nearby, is a quaint town founded in 1626, and contains many fine old colonial residences, including The Witch House, and the House of Seven Gables. Marblehead, with its excellent harbor, is now a yachting center and is also the birthplace of the American Navy. About 25 miles away is America's greatest fishing port, Gloucester, established in 1625, and celebrated throughout the world for its fishing schooners.

Lexington and Concord, the home of patriots and famous for the first Revolutionary battles, are rich in historic sites. The line of the Minute Men is appropriately designated on the Lexington Common, and the John Hancock house may be seen with its original furnishings.

At Sudbury the Wayside Inn contains many interesting relics and was made famous by Longfellow in his Tales of the Wayside Inn. Washington, Franklin and Lafayette were among the honored guests of the inn.

Plymouth, or Pilgrim Land, important in New England legends, includes within the town limits Plymouth Rock, the landing place of the Pilgrims, and Pilgrim Hall, where a splendid collection of authentic Mayflower relics will be found.

The call is—To New England in June.

Semi-Annual Meeting 1931

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
New Ocean House, Swampscott, Mass.,
June 22-25, 1931

Monday, June 22

8:30 A. M. Registration
12:30 P. M. Luncheon (Authors and Council)
2:00 P. M. Council Meeting
3:00 P. M. Research Committee
8:00 P. M. Concert
9:00 P. M. Reception and Dance

Tuesday, June 23

9:30 A. M. Technical Session
2:00 P. M. Sports and Entertainment Program for Members and Ladies

Wednesday, June 24

9:30 A. M. Technical Session
2:00 P. M. Golf Tournament (Research Cup)—North Shore Country Club
7:00 P. M. Semi-Annual Banquet and Dance

Thursday, June 25

9:30 A. M. Technical Session
2:00 P. M. Sports and Entertainment Program for Members and Ladies

D. S. BOYDEN, CHAIRMAN,
COMMITTEE ON ARRANGEMENTS

Come to Swampscott
in June
for
1931
Semi-Annual
Meeting

W. T. JONES, VICE-CHAIRMAN
COMMITTEE ON ARRANGEMENTS

Local Chapter Reports

Cleveland

February 18, 1931. The February meeting of the Cleveland Chapter, which was called to order by Pres. F. H. Morris, was held in the rooms of the Cleveland Engineering Society.

Following the routine of business the meeting was turned over to the speaker of the evening, Webster Tallmadge, who spoke on Zone Heating, which he illustrated with lantern slides describing the steam flow through a building, characteristics of flow through orifices, remote control of valves, zoning arrangement of heating systems, and many other interesting things.

The interest of the members in heating system control was indicated by the various questions that Mr. Tallmadge was requested to answer.

The attendance was above average, helping to make the meeting one of great interest.

Kansas City

February 9, 1931. The Kansas City Chapter held its February meeting at the Ambassador Hotel, with 24 members and guests present. The discussions and talks were of such unusual interest that the meeting did not adjourn until long after the usual closing hour.

The meeting was called to order by Pres. E. K. Campbell, who conserved time by dispensing with routine matters to give time to important subjects at hand, and for the enjoyment of the program prepared by Vice-president Arthur.

N. W. Downes reported on his activity in behalf of the Chapter, regarding important proposed legislation advocated in recent meetings of the Architects and Engineers Council. The proposed registration law for professional engineers was read and discussed, and inasmuch as a bill for the licensing of architects in the State of Missouri is coming up before the present Assembly at Jefferson City, it was thought proper to present the proposal for registration of engineers at the same time, and to get an immediate expression from members of the Society.

After much enlightening discussion on the subject it was moved by Carl Clegg, and unanimously carried that the Kansas City Chapter endorse the proposed registration law for professional engineers in the State of Missouri.

Prof. S. H. Sluss invited the members to the University of Kansas, Lawrence, on March 18, where Dr. S. P. Grace of the Bell Telephone Laboratories of New York City will lecture under the auspices of the School of Engineering and Architecture. Several of the technical developments which have been worked out in these laboratories, will be explained and demonstrated.

A confidential talk was then given by Colonel Edwards, who is one of the outstanding men occupying the position of Chief of Police in Kansas City, and is serving most effectively on various Law Enforcement Committees locally and nationally. Colonel Edwards spoke on Law Enforcement, which was very interesting and enjoyed by the members and guests present.

Massachusetts

February 26, 1931. The February meeting of the Massachusetts Chapter of the Society was held in connection with the *American Society of Refrigerating Engineers* meeting in the Chamber of Commerce Bldg. in Boston, with an attendance of 110 members and guests.

After dinner brief remarks were made by President Fitz and Secretary Ryan of the Refrigerating Engineers Society and by Pres. T. F. McCoy of the Massachusetts Chapter, A S H V E.

The guest speaker of the evening was D. C. Lindsay, of Newark, N. J., who addressed the meeting on Modern Trends in Air Conditioning. Mr. Lindsay cited numerous undeveloped opportunities for air conditioning systems and told of the probable rapid increase of this type of apparatus during the coming years. He presented lantern slides showing a variety of applications of air conditioning and cooling, which interested the members and guests present. A fine discussion followed.

Michigan

February 9, 1931. The Detroit Edison Co. were hosts to the Michigan Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. This is an annual event and has become an outstanding occurrence in the annals of the Michigan Chapter. After dinner, which was served in the restaurant of the Edison Company's main office building, the 95 members and guests assembled in the auditorium for an entertainment program.

Following the entertainment Pres. E. E. Dubry opened the meeting by introducing S. S. Sanford, heating engineer with the Detroit Edison Co., whose subject was, Modern Methods of Saving Heat in Buildings. Mr. Sanford has had charge of tests which have been run on more than a dozen office buildings in Detroit and the information which he presented was all based on the results of his investigations.

He brought out the fact that his tests have shown that in most tall office buildings not enough consideration has been given to the stack effect which exists in practically all cases. He urged that this be taken into account by increasing the heating surface on the lower floors and decreasing the radiation on the upper floors. He also brought out the fact, which is not generally known, that the upper part of a tall office building does not cool off at night as quickly as does the lower part of the building.

Mr. Sanford had charts to show that a heat saving in steam consumption can be made in an office building if the steam is turned off at night. Contrary to the opinion of a large percentage of engineers, he has found that it is far more economical to turn off the steam as early as possible in the evening and leave it off until the following morning, turning it on then in sufficient time to bring the building to the proper temperature before it is occupied. In the first place, apparently the building does not cool as quickly or as much at night as the average engineer would expect and in addition, it is not as difficult to bring it up to temperature in the morning as the average engineer thinks it is.

Mr. Sanford went into the control of heating systems in office buildings, touching on intermittent heating, controlled by thermostats, the varying steam pressures or vacuum, and the fractional heating of radiators by hand modulating valves, by wall thermostats or thermostatic radiator valves and radiator orifices. He expressed the opinion that the radiator orifices were the best type of control where the system was controlled from a central point and the pressure was varied with the outside temperature.

Following Mr. Sanford's very complete and enlightening discussion numerous questions were asked by the members.

The next speaker of the evening was J. H. Walker, also with the Detroit Edison Co., whose subject was, Modeling as Applied to Pipe Design. To illustrate the point that by making an actual model of a job, the installation of the piping was not only simplified for the engineer and draftsman, but it looked a great deal better, Mr. Walker showed a picture of a unit with all its

piping connections which had been installed before they began to make models and then he showed another picture of the same unit with its piping connections which were designed from a model.

Following Mr. Walker's talk a very interesting discussion took place, which brought the February meeting to a close. It was the consensus of opinion that this was one of the most enjoyable evenings of the year.

Minnesota

February 16, 1931. Thirty-five members and guests gathered at the St. Paul Athletic Club for the February meeting of the Minnesota Chapter of the Society, at which Pres. D. M. Forfar presided.

M. S. Wunderlich, representative on the Nominating Committee at the Annual Meeting of the Society, reported on the candidates considered for 1931.

Prof. F. B. Rowley gave a report on many interesting meetings held at the meeting in Pittsburgh, and spoke also of the excellent work being done by the Research Laboratory of the Society in Pittsburgh, and how this was made possible by Society support through membership dues.

President Forfar expressed his appreciation for the honor bestowed on the Minnesota Chapter in selecting Professor Rowley as first Vice-president of the Society. He also mentioned the splendid work done by the Minnesota Chapter in the recent membership drive, as a result of which, the Minnesota Chapter was awarded the banner for the largest percentage of new members obtained during the year.

Albert Buenger and E. F. Jones outlined briefly the many unique heating and ventilating problems in connection with the design of systems for the Northwest Airway Hangars and Shops, and the 109th Aero Squadron. These are both oil fired boiler, unit heater installations with automatic control.

After considerable discussion on these installations the meeting adjourned for an inspection trip through the plants.

Philadelphia

February 12, 1931. The regular monthly meeting of the Philadelphia Chapter was held at the Engineers Club, with Pres. E. N. Sanbern presiding.

President Sanbern introduced the speaker of the evening, Lee P. Hynes, a member of the Chapter, who presented a most interesting talk on Heating by Electricity. Mr. Hynes outlined the various industries that now employ this form of heat in the manufacture of their products, and demonstrated the different types of heaters, explaining the progress that has been made in the manufacture and design of the numerous resistants. He also outlined different methods of producing heat by electricity, and types of heaters that have been used successfully up to the present time. This subject was the first of its kind presented to the Chapter, and proved to be a very interesting topic.

After a rising vote of thanks had been extended to Mr. Hynes, J. F. Gaskill, assistant engineer of power sales for the Philadelphia Electric Co., gave a short talk outlining the work that was being done to further the use of electric heating in Philadelphia.

Mr. Mensing then made an appeal for members of the Society to become members of the Engineers Club, stating that it was necessary for the members, as engineers, to help carry on organizations that were interested in engineering societies such as the Engineers Club.

Following the reading of the Committees with their respective chairmen that have been appointed to function during President Sanbern's term, the meeting was adjourned.

Ontario

March 2, 1931. The Ontario Chapter of the A. S. H. V. E. held its monthly meeting at the Prince George Hotel, where 57 members and guests enjoyed dinner and a very pleasant evening.

After dinner Esten Bolling, consulting engineer, spoke on the subject of An Engineered Home Makes Home—Sweet Home. This address dealt chiefly with an air conditioning experiment in a home, and in conclusion he predicted new practices in heating and ventilating in homes of the future.

The members and guests of the Ontario Chapter were also fortunate in having with them such prominent members of the Society, as C. W. Farrar, Buffalo, N. Y., chairman of the Committee on Increase of Membership, and A. V. Hutchinson, New York, N. Y., Secretary of Society. Following a brief talk on the increased membership by Mr. Farrar, Mr. Hutchinson spoke on the activities of the Society during the past year and outlined briefly the plans for the coming year, which was thoroughly enjoyed. E. Holt Gurney gave a splendid resumé of the work of the Society during the Pittsburgh meeting and expressed his enthusiasm for the good work being accomplished by the Society.

A. J. Dickie extended a vote of thanks to the guests of the evening, which was followed by adjournment.

Western New York

February 7, 1931. The Society's Western New York Chapter held its annual dinner dance in the ball room of the Hotel Buffalo with an attendance of 92 members and guests.

Roswell Farnham acted as toastmaster of the evening, which task he very ably fulfilled.

F. H. Burke, the retiring president, expressed his appreciation for the cooperation of the committees and members in making the past year of the Chapter a success, and at the conclusion introduced Joseph Davis, who was elected president for the ensuing year. Mr. Davis asked for the continued cooperation of the members which has brought about the large attendance at the last year's meetings. The other incoming officers were then introduced and in turn, each responded briefly and pledged his support to the new president.

Roswell Farnham, continuing his task, presented the A. S. H. V. E. watch to Joseph Davis for obtaining the largest number of new members for the Society during the past year when he was chairman of the Membership Committee.

W. G. Fraser, Hugo Hutzel, C. A. Evans and M. S. Jackson, all past-presidents of the Chapter, were then introduced, each in turn commending the success of the Chapter during the past year under the leadership of Mr. Burke.

The members and guests enjoyed a more than pleasant evening, and very few left before the orchestra at 2:00 A. M.

St. Louis

March 4, 1931. The March meeting of the St. Louis Chapter of the Society was held at the Roosevelt Hotel, with 19 members and guests present when the meeting was called to order by Pres. R. M. Rosebrough.

After the regular order of business had been taken care of, the meeting was turned over to L. Walter Moon, chairman of the Program Committee, who advised that Rodney Smith, of W. B. Ittner, Inc., scheduled to appear at this meeting to discuss the subject of The Evolution of School Heating and Ventilating, had been called out of town and was unable to be present.

Mr. Moon then introduced C. L. Bailey, Republic Steel Corp., who exhibited three rolls of films prepared by the U. S. Bureau of Mines, under the Department of Commerce for their Library, pertaining to the making of alloy steel. The description of this process and the films were educational and much appreciated by the St. Louis Chapter members and guests present.

A rising vote of thanks was given to Mr. Bailey for the profitable evening afforded the local Chapter.

Of Interest to Members

President Carrier's Itinerary

Pres. W. H. Carrier will visit the Western Chapters during March and April and the topic that he has chosen for discussion is entitled Servicing the Human Power Plant.

The first appearance will be in Los Angeles, March 31, for the Southern California Chapter members.

On April 3, a visit will be made to San Francisco, where a meeting of members in that city has been arranged.

Going North, President Carrier will visit Seattle, April 6, for a meeting with the Pacific Northwest Chapter members.

On April 10 he is scheduled to talk before the Minnesota Chapter members, Minneapolis, and on April 13, will be the guest of the Illinois Chapter in Chicago.

The Kansas City Chapter has planned a special April Meeting to entertain Mr. Carrier at the University of Kansas, in Lawrence, on the 14th, and on April 16 he will appear before the engineers of Cincinnati.

Society Sponsors Paper at Printing Conference

A paper entitled, Relation of Standardization to Air Conditioning in the Printing Industry, by W. H. Carrier, which was sponsored by the Society, was presented in Mr. Carrier's absence by D. C. Lindsay at the Second Conference of Technical Experts in the Printing Industry held in the Government Printing Office, Washington, D. C., March 16 and 17, 1931. An abstract of this paper appears on page 335 of this issue.

Discussions on the engineering construction and operation of specific machines or systems were prepared by F. F. Bahnson, The Bahnson Co., Winston-Salem, N. C.; R. T. Williams, Carrier Engineering Corp., New York; W. L. Souther, The Cooling and Air Conditioning Corp., New York; B. Offen, B. Offen and Co., Chicago, Ill.; R. H. Brown, Parks-Cramer Co., Boston, Mass.; G. A. D'Arcy, Rhode Island Humidifier and Ventilating Co., Boston, Mass.; C. A. Segner, Vapo Systems, Chicago, Ill.; M. T. Barnum, The Wilcolator Co., Newark, N. J. These discussions were printed in advance of the meeting and those by Messrs. Bahnson, Williams, Brown and Barnum were personally presented in abstract.

The presentation of the paper, and the discussions thereof, was followed by a group conference on air conditioning data for printing, which was presided over by Mr. Davis of the Mt. Pleasant Press, Harrisburg, Pa. This conference was attended by 16 representatives of manufacturers of air-conditioning equipment, and many interesting side-lights on the subject developed.

Among other things, it was emphasized that air conditioning in itself is not a panacea for all printing problems, and that the air-conditioning man must also have the co-operation of the paper manufacturer and of the printer himself, as the effectiveness of the air-conditioning installation is greatly diminished without the proper co-ordination of these other factors. The discussion included reference to the hygroscopic properties of paper and the relation of air conditioning thereto, as well as the humidities desirable under summer and winter conditions when other economic factors are considered.

Chicago Will Entertain Council Members

The next meeting of the Council is to be held at Chicago, Ill., on April 13, at the office of the Board of Education, 188 W. Randolph Street.

Through the courtesy of John Howatt, arrangements have been completed for the meeting at which one of the important considerations will be the Society budget for the coming year.

The Illinois Chapter has invited all of the Officers and members of the Council to be guests of honor at the April meeting of the Chapter in the Hotel Sherman, where Prof. G. L. Larson, of the University of Wisconsin, and Pres. W. H. Carrier are expected as the guest speakers.

W. H. Driscoll Addresses Eastern Supply Association

W. H. Driscoll, vice-president, Thompson-Starrett Co., New York, and past-president of the A.S.H.V.E., delivered an interesting address on current business conditions at the spring meeting of the *Eastern Supply Association* which was held at the Hotel Astor, New York, March 11 and 12, 1931.

Mr. Driscoll expressed the opinion that there was no definite reason for the mental perturbation so many people have undergone during the past six or eight months, as depressions are old and have passed, to be followed by periods of business on higher economic levels. Placing the blame on the financiers for the tone of pessimism surrounding business, Mr. Driscoll stated that bankers have tried to establish causes for the depression, including over-production and under-consumption. He continued to explain how business is governed by traditions and rules instead of sound practice and suggested that only profitable commodities be handled by wholesalers. The main trouble, he pointed out, lies in the extension of long term credits. In this respect, Mr. Driscoll said, "The plumbing and heating industry can never be the business it should until credits are eliminated and it is put on a cash basis. Your objection to this will be that you have always extended credit and cannot change, but you can—not in a few months but in time, if you definitely apply the principle."

Mr. Driscoll reminded the audience that building operations which create the market for plumbing and heating materials are cash propositions through financing and that the plumbing and heating contractor, if he bought for cash, would of necessity, be more accurate in figuring and would ultimately be a better business man. Funds, he explained, would be available to the contractor from banks, just as they are to other business men, within the limits of their capacity. This, he pointed out, would prevent the taking of contracts by contractors incapable of handling them. In conclusion, Mr. Driscoll stated that this proposal is, no doubt, a radical and revolutionary change, but the manufacturer, jobber or contractor will not reach the position of importance he should occupy until it is done.

Numerous interesting reports and addresses were presented before the meeting, at which there was an unusually large attendance.

Warm Air Heating Association Meeting

The National Warm Air Heating Association will hold its 18th annual convention at the Deshler Wallick Hotel, Columbus, Ohio, April 22 to 23, 1931. In addition to the general sessions, there will be a group meeting of manufacturers and one of dealers with special programs.

All phases of the industry will be covered, including air conditioning, use of different fuels, better business, research,

forced air, engineering, merchandising, and commercial conditions. One of the interesting topics to be discussed at the Dealers' Session on Wednesday morning, April 22, is Air Conditioning the American Home, which will be presented by J. C. Miles, Cleveland, Ohio.

On that afternoon at the first general session for manufacturers, dealers and guests, V. S. Day, Newark, N. J., will present a paper entitled, "Experience in Residential Air Conditioning." Following Mr. Day's presentation, E. B. Langenberg, St. Louis, and C. B. Huntress, executive secretary of *The National Coal Association,* will discuss the progress made by the Committee of Ten.

At the second general session, Thursday morning, April 23, "Summarized Conclusions of Latest Information Relative to Our Research Work" will be presented by Prof. A. C. Willard, head of Department of Mechanical Engineering, Prof. A. P. Kratz, Research, and S. Konzo, special research assistant, all of the University of Illinois, Urbana, Ill.

Plans for the extension of the Association will be a special feature at the meeting.

Eighth Annual Convention and Oil Burner Show

The eighth annual convention and oil burner show of the *American Oil Burner Association* will take place at Philadelphia during the week of April 13 to 18, 1931. Convention headquarters will be at the Benjamin Franklin Hotel. The Show which is to be held in the Gimbel Bldg., across the street, will follow the policy inaugurated last year of opening the Exhibit Hall to the general public. More than 80 firms will be represented in the exhibit hall and over 120 booths have been taken for the equipment.

Engineers are particularly urged by the Association to attend this annual event to see and hear of the progress the industry has made. Many manufacturers of oil burners and accessories have conducted extensive research programs during the past year with the result that they are expected to exhibit new and improved types of burners. The few years that have elapsed since the oil burner business secured its first practical recognition from the American people, have witnessed an amazing growth, but there are always problems to solve—whether they be manufacturers, dealers, or individuals. No better opportunity for a discussion of these troubles can be found than at the annual convention.

Outstanding subjects will be discussed by men qualified to discuss them and everyone is invited by the Association to be present and to contribute to the exchange of ideas and personal experiences. Two days will be devoted to merchandising sessions and another day to engineering sessions in addition to the annual meeting of the members. New officers and director also will be elected at this time.

Not only a repetition but an increase of the large audience which attended the sessions last year in Chicago, is anticipated at the Philadelphia show.

Marks Handbook

The 3rd edition of Marks Mechanical Engineers' Handbook contains a considerable amount of new and useful data of value to the heating and ventilating engineer.

The section on heating and ventilating, in which the A. S. H. V. E. Guide is quoted freely, has been ably edited by Prof. J. E. Emswiler of the University of Michigan, a prominent member of the Society. W. H. Carrier, newly elected president of the Society, has contributed the section on air conditioning and drying.

In addition, this handbook contains special sections on other subjects in which the heating and ventilating engineer is interested, such as fuels and furnaces, fans and blowers, pipe and fittings, building construction, mchanical refrigeration, and pumps.

Marks Mechanical Engineers' Handbook is published by McGraw-Hill Book Company, 370 Seventh Ave., New York, N. Y.

Six-Place Tables

The 4th edition of Six-Place Tables, compiled by E. S. Allen, Associate Professor of Mathematics, Iowa State College, has recently been issued.

This volume was originally prepared in response to a strong demand for a pocket-size book of tables such as are in regular use by engineering students and instructors, as well as by graduate engineers in their professional work.

It contains a selection of tables of squares, cubes, square roots, cube roots, fifth roots and powers, circumferences and areas of circles, common logarithms of numbers and of the trigonometric functions, the natural trigonometric functions, natural logarithms, exponential and hyperbolic functions, and integrals.

As it is of course impossible to include all integrals of rational fractions, a concise but adequate account of their separation into partial fractions has been included.

This book is published by the McGraw-Hill Book Co., Inc., of New York.

Designing Heating and Ventilating Systems

The 3rd edition of Designing Heating and Ventilating Systems, by Charles A. Fuller, Consulting Engineer, has recently been issued.

This book was developed from a series of lecture courses given at several institutions, before audiences of varying experience and education in the heating line.

The theory of both heating and ventilation is handled in such a manner as to eliminate as far as possible the most difficult mathematical computations and expressions, and at the same time is handled in a thorough and exhaustive manner.

The subjects covered include the heat unit, heating value of coal, relation of heat and work, loss of heat from buildings, classification of heating systems, heat transmission through radiators and coils, flow of steam in pipes, pressure drop in steam mains, gravity systems, vapor systems, vacuum systems and vacuum valves, piping for vacuum systems, vacuum pumps for vacuum heating systems, indirect systems, boilers, hot water systems, furnace heating, hot-blast heating, duct systems for factory ventilation, school ventilation, theater ventilation, hotel ventilation, heating stacks, arrangement of heaters, individual duct system, ventilating fans, estimating static pressures, fan motors, temperature regulation, recirculation of air, air washers, estimating coal consumption, high pressure steam for cooking, laundry and process work, high pressure boiler room piping and auxiliaries.

This book is published by Scientific Book Corporation, New York.

Beg Pardon

In the tabulation of funds appearing with the Report of the Committee on Research on page 250 of the March issue it was incorrectly indicated that pledges for 1930 were still due from two manufacturers. Apology is made to Barnes & Jones and Wolverine Tube Co. for this erroneous reference.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the name of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 16 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some members by April 15, 1931, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
CHASE, LOUIS RICHARD, Br. Mgr., Buffalo Forge Co., Kansas City, Mo.	C. A. Booth C. C. Cheyney	R. D. Madison R. T. Thornton
CHRISTMAN, WILLIAM F., Theatre Air Conditioning Engr., Carrier Engrg. Corp., New York, N. Y.	O. W. Armspach A. C. Buensod	M. H. Darby A. S. Henry, Jr.
GOENAGA, ROGER CHARLES, Technical Director, Ateliers Ventil, Lyon, France.	A. Beaurrienne André Nessi	
HAGERMAN, JAMES J., Dist. Mgr., Heating & Ventilating Div., Bishop & Babcock Sales Co., Chicago, Ill.	H. G. Kreissl H. R. Linn	Albert Pelletier S. I. Rottmayer
KELLY, CHARLES J., Sales Engr., Jas. P. Marsh & Co., New York, N. Y.	C. F. Ames R. H. Carpenter	M. G. Hook A. H. Hills
LEVY, MARION I., Bishop & Babcock Sales Co., Cleveland, Ohio.	S. H. Givelber F. H. Morris	C. F. Eveleth R. G. Davis
MACK, ARTHUR PRESCOTT, Head of Department of Plumbing & Heating, Tuskegee Normal and Industrial Institute, Tuskegee, Ala.	S. E. Dibble T. M. Dugan	F. C. Houghten Peter O'Neill
MAY, EDWARD M., Supt., Combustioneer, Inc., Goshen, Ind.	C. W. Plass H. R. Linn	
MAYNARD, J. EARLE, Heating Engr., Fox Furnace Co., Elyria, Ohio.	S. H. Givelber H. M. Nobis	C. F. Eveleth F. H. Morris
NEWMAN, CHARLES THOMAS, Owner, C. T. Newman, 2729 Hooper Ave., Los Angeles, Calif.	O. W. Ott Harrold English	J. S. Earhart H. B. Keeling
ROGERS, VERNON A., Private Practice, Center Moriches, N. Y.	R. C. Willis L. G. Paulding	H. W. Hochuli C. E. Scott
REILLY, J. HARRY, Br. Engr., American Radiator Co., Newark, N. J. (*Advancement*)	F. W. Johnson O. O. Oaks	W. R. Zuhlke J. P. Schoener
SHAWLIN, WALTER C., Pres. & Genl. Mgr., Northwestern Fan & Blower Co., Milwaukee, Wis.	F. F. Deolshagen A. Christiansen	
SMAIL, A. MELVILLE, Engineer-Custodian, Board of Education, Chicago, Ill.	John Howatt J. J. Finan	J. P. Fleming E. J. Finan
STERNBERG, EDWIN, Carrier Engrg. Corp., New York, N. Y.	O. W. Armspach A. C. Buensod	M. H. Darby A. S. Henry, Jr.
WALLACE, KENNETH S., House Heating Supervisor, The St. Louis County Gas Co., Webster Groves, Mo.	R. M. Rosebrough G. A. Helwig	E. S. White C. A. Pickett

Candidates Elected

In past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Membership Committee and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. II, Sec. VIII, of the By-Laws, the following list of candidates elected:

MEMBERS

BODINGER, JACOB HARRIS, President, J. H. Bodinger Co., Inc., New York, N. Y.

CAREY, THOMAS M., Sales Repr., Herman Nelson Corp., Defiance, Ohio.

COLE, EDWIN QUINCY, Sales Engr., The Herman Nelson Corp., Springfield, Mass.

HEATH, WILLIAM R., Asst. Chief Engr., Buffalo Forge Co., Buffalo, N. Y.

JOHNSON, LOUIS HENRY, Owner, L. H. Johnson Co., Minne-City, Mo.

JOHNSON, LOUIS HENRY, Owner, L. H. Johnson Co., Minneapolis, Minn.

KILLEEN, EDMUND FRANCIS, Sales Repr., The Herman Nelson Corp., Duluth, Minn.

LEONARD, JOSEPH HAMILTON, Mfgr's. Repr., J. T. Leonard Co., Winnipeg, Manitoba, Canada.

MAGNEY, GOTTLIEB RENATUS, President, Magney & Tusler, Inc., Minneapolis, Minn.

MARKUSH, EMERY U., Mech. Engr., Weitbeer Plumbing Corp., New York, N. Y.

MARUM, OTTO, Plant Engr., Agfa Ansco Corp., Binghamton, N. Y.

MORRISON, CHESTER B., Vice-Pres. & Genl. Mgr., York Shipley, Inc., Shanghai, China.

MURRAY, WOODWORTH NORTHEY, Sales Repr., The Herman Nelson Corp., Boston, Mass.

PURCELL, HAROLD THOMAS, Partner, Southern Sales Co., Nashville, Tenn.

RACK, EDGAR C., Staff Mgr., Engrg. Dept., Johns-Manville Corp., New York, N. Y.

ROOKS, ALFRED WENDELL, Sales Repr., The Herman Nelson Corp., Cincinnati, Ohio.

SCHULTE, ROSS R., Owner-Consulting Engr., R. R. Schulte, St. Paul, Minn.

SHELNEY, THOMAS, President, Pierce Blower Corp., Buffalo, N. Y.

SPOODIS, ANTHONY, Sales Repr., The Herman Nelson Corp., Moline, Ill.

THORNTON, WILLIAM BARRY, Br. Engr., Carrier-Lyle Corp., Pittsburgh, Pa.

WYMAN, DWIGHT M., Sales Repr., The Herman Nelson Corp., Barrington, R. I.

ASSOCIATES

BARNETT, STEPHEN J., Sr. Partner, Barnett Brothers, Buffalo, N. Y.

BOWES, FRANK RICHARD, Sales Repr., Herman Nelson Corp., Boston, Mass.

DOCKERAY, FAYETTE, Sales Repr., The Herman Nelson Corp., Kingston, Pa.

JARRATT, PAUL R., Partner, Southern Sales Co., Nashville, Tenn.

KEIST, WALTER EARL, W. J. Keist & Son, West View, Pittsburgh, Pa.

LINDSEY, WILLIAM JUDSON, Salesman, The Herman Nelson Corp., Peoria, Ill.

WHEELER, CHARLES A., Sales Repr., The Herman Nelson Corp., Des Moines, Iowa.

JUNIORS

BUR, JULIEN R. C., Bur et Cie, Dijon, France.

FRITZBERG, HILDING L., Student Engr., Carrier Engrg. Corp., Newark, N. J.

O'HAVER, HUBERT MAURICE, American Blower Corp., Los Angeles, Calif.

TAVANLAR, ELIGIO J., Yale University, New Haven, Conn.

STUDENTS

ETHERIDGE, GEORGE THOMAS, JR., Student, Carnegie Institute of Technology, Pittsburgh, Pa.

NORDHEIMER, CLYDE L., Student, Carnegie Institute of Technology, Pittsburgh, Pa.

Heating·Piping and Air Conditioning EDITORIALS

"In These Times"

During the last year or so, in advertisements, articles, or conversation, we frequently run across the statement, "In these days of business depression, first costs and maintenance costs must be reduced." We've been guilty of it ourselves.

While this is true enough—and perhaps is especially pertinent in such times—half the statement is extraneous material. First costs—and maintenance costs—must *always* be kept at a minimum for economic operation. Every engineer must keep in close touch with improvements in processes and equipment.

Only by continually whittling costs to the economic minimum can the engineer be satisfied that he is doing his job, whether business volume be large or small. "A penny saved is a penny earned"; the same proverb holds true for dollars.

A Helpful Supplement

There are several meetings to be held during April which should have something of considerable value to offer the heating, the piping or the air conditioning engineer. Among them are the annual convention of the *National Warm Air Heating Association,* the scene of which is Columbus, Ohio; the *American Oil Burner Association* convention, which meets in Philadelphia, Pa.; and the annual meeting of the *American Welding Society* at New York City. There are also the *National Management Congress,* which many engineering executives will want to attend in Cleveland, Ohio, and the semi-annual meeting of the *American Society of Mechanical Engineers* at Birmingham, Ala.

Many engineers and contractors realize the advisability of attending the conventions and other meetings of the organizations which fit into their particular field or fields. The decision as to what meetings cannot be missed should rest on the fundamental problem of balancing the investment in time and money against the estimated advantages that can be derived in new ideas and from contact with men with similar interests.

There are few meetings that do not repay amply the man who attends with a mind determined to take home an idea or a suggestion which will make his work more effective and, therefore, more profitable. Attendance at such conventions is a helpful supplement to the regular reading and study of his engineering paper.

A Few Charts

The chief maintenance engineer of a large industrial plant says, "It is better to have a few charts reach the maintenance or operating engineer's desk every day, and be carefully studied, than to have an accumulation of charts come to his desk and be given no thought."

Records and charts are of no inherent value in themselves; the mere obtaining of such data without using it is a waste of time. However, when such records are used from day to day, week to week, month to month, or year to year, they are of invaluable benefit in assisting the engineer to operate his equipment satisfactorily and economically.

Modern industry is based on knowledge that can be relied upon. The industrial engineer must know how his pipe lines are behaving, how his heating system is functioning, and the conditions that are being maintained by his air conditioning equipment. But having the information available is not the only requirement. Only through intelligent and regular study of such charts can their full value be realized.

"April Fool"

There are few of us who haven't kicked an old top hat reposing innocently on the sidewalk, only to find that it concealed a brick or two. Or maybe we've accepted a piece of candy, discovering its soap content too late. The date generally turns out to be April 1.

The purpose of all this is not to put any mischievous ideas in your heads; we are going to point out a moral.

Just as on April 1st we must be careful of all these little things, it behooves us to investigate the meaning of the word "modern" throughout the year. Every new office building, industrial plant, theater, or public building is called "modern."

Most of the buildings being planned and constructed these days provide for the conditioning of the atmosphere. But unless such provisions are made, the building cannot be called "modern." The almost innumerable advantages of real air conditioning are well-recognized today; there is no excuse for applying the term "modern" to a structure in which air conditioning could be applied, if that building is heated only or ventilated only.

There is no place for April fool jokes in industry or business; and they're becoming harder to play, too.

Some Reports on Research

M. L. Duckman, Plant Engineer, Firm Believer in Complete Records on Air Conditioning System Performance

Air Conditioning Vital in Silk Spinning

HUMIDIFICATION has been used in the textile industry for many years, but precision control was not employed at first. Conditions fluctuated and no need was formerly seen to modify the prevailing air conditions on the basis of actual tests of fiber strength, evenness, and freedom from splits and breaks in relation to conditions in the plant. Humidity was considered important, but the importance of constant heat was not appreciated.

M. L. DUCKMAN

Two things have helped to improve this situation: (1) Recording instruments have been applied with automatic control. These instruments enable the consistent adjustment of conditions to the process; and (2) technical tests of strengths, textures and extensibility are used that prove what economic values hinge upon controlled air conditions and just what ranges of control are favorable to high standards in the finished product.

Silk fiber is, of course, highly hygroscopic. The standard tests weigh out the fiber in a given atmosphere of low relative humidity. If weight-gain in a humid atmosphere is 6 pounds in 100 pounds original weight of bone dry raw material, the *regain* is said to be 6 per cent. This regain is not constant but it is the factor that fixes the operation of the air conditioning system of the plant.

Strength and Humidity

Strength tests bear out the value of precision in air conditioning. There is consistently greater strength with high humidity. For every 1 per cent increase in relative humidity, in terms of standard strength at 70 per cent, the strength index of the textile fiber increases 0.2 for cotton, 0.4 for flax, 0.1 for jute, and 0.6 for silk. Conditioned air means better workability and fewer yarn breakages. Silk mills particularly have to allow for the influence of humidity on yarns. Heat relationships are important, too. Control work in a silk mill means careful engineering, continuous tests, and exact knowledge of the processing.

Oscar Heineman Silk Mill

All these are well brought out in the control routines observed in the new, modern silk mill of the Oscar Heineman Corp., Chicago. Its routine records represent reliable scientific contributions to air conditioning practice in the silk industry.

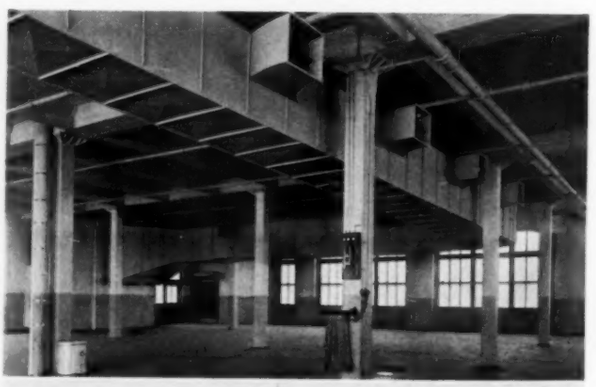
In this plant the manufacturing cycle takes five full days between the opening up of the raw bales of silk in the basement until the finished cones of four-ply thread are ready for the market. The thread goes chiefly to the silk stocking trades.

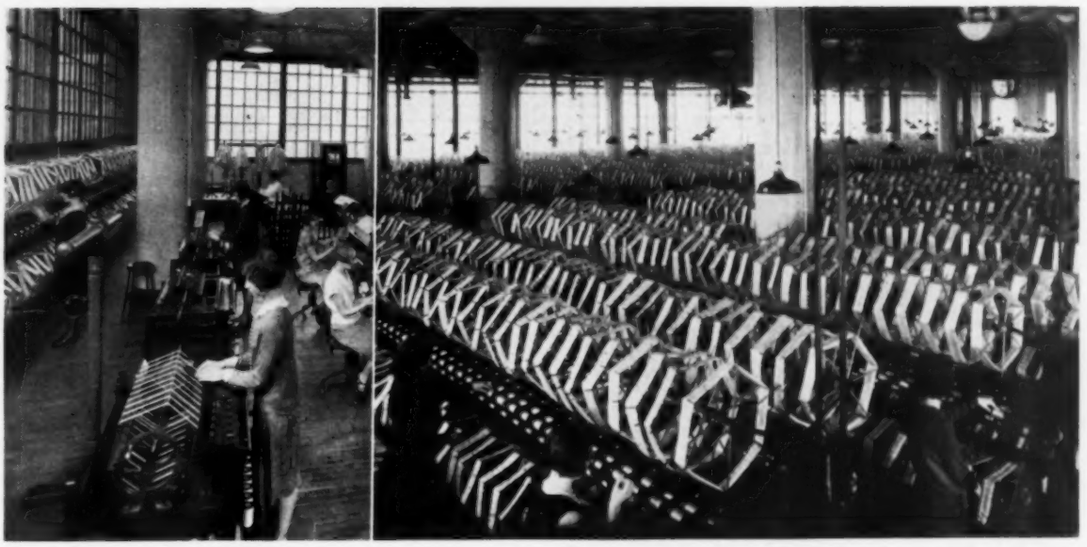
Favorable operating conditions for manufacture set the normal range of temperature for all the floors between 70 and 75 degrees F. Above 75 degrees in plant parlance is called high; less than 70 degrees is rated low. The relative humidity is held at 75 per cent. Conditions do not vary throughout the manufacturing cycle, and are the same on every floor of each building. The floors are separately recorded and regulated.

Records Important

M. L. Duckman, engineer of the plant, believes in automatic records. He has in a large master dial above his desk, a continuous index of the air pressure lines throughout the building that operate the temperature and humidity controls. Hygrometers are used with recording instruments for temperature. All other instruments are of the automatic recording type. Results must tally at all points and the instruments themselves receive extremely careful supervision. Mr. Duckman's graphs show continuous operation records for the past ten years; they

ABOVE—A SECTION OF THE FACTORY BEFORE OCCUPANCY, SHOWING THE AIR INLETS. RECORDING THERMOMETERS ARE LOCATED ON THE CENTRAL COLUMN. BELOW—A VIEW OF MILL NO. 4, OSCAR HEINEMAN CORPORATION





LEFT—THE TESTING DEPARTMENT, WHERE PANELS ARE MADE AND DEFECTS ARE SUBJECTED TO VISUAL COUNTING. RIGHT—A VIEW OF THE WINDING SECTION IN MILL NO. 4

include "roof readings" of outside temperature and relative humidity.

As an additional check upon the accuracy and functioning of the recording instruments and controls, a man goes through the works every second hour, jots down the wet and dry bulb readings and records the relative humidity at seventeen different points within the plant.

Recirculation

Recirculation is practiced in extremely cold weather, 30 per cent of recirculated air being the maximum at any time. In silk manufacturing processes there is always the recognized possibility of cumulative odors. The air supply is always in excess of usual requirements for good ventilation and slight positive pressures are built up within the rooms.

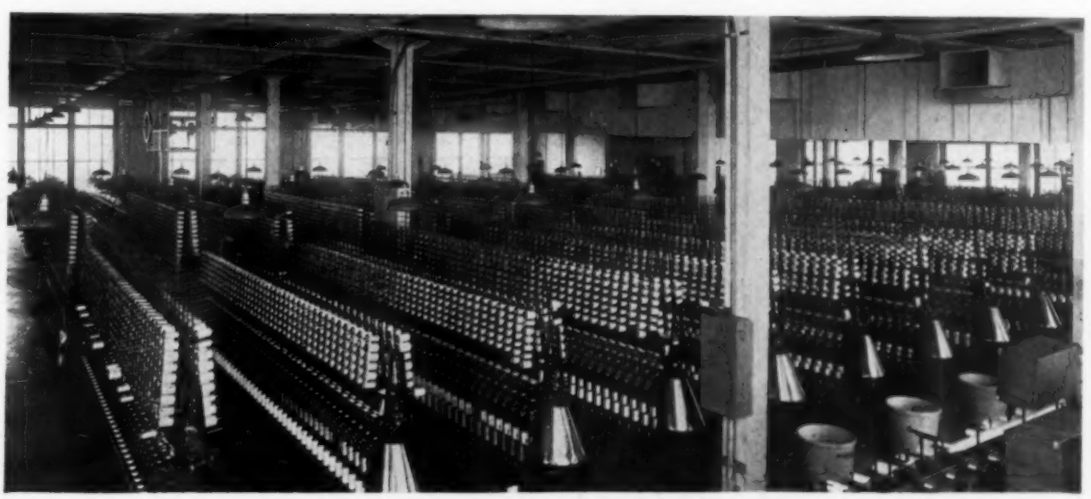
Preventing Condensation

In building No. 4, an unbroken band of windows encircles the building. All of them are sealed shut with plastic cement and double windows are used throughout to avoid difficulties from condensation of excess moisture on the panes. The space between the double panes is drained by copper gutters through small pipes that lead down to copper drains at the floor level of the external walls. This takes care of any condensation that tends to form on the outside walls in winter time. The small inter-window drain pipes had to be equipped with valves to prevent ascending air from the work rooms causing any excess condensation or frosting between the panes.

Condensation everywhere is recognized as an ever-present difficulty, and the utmost attention is paid to insulation. Roofs are cork insulated and all water pipes and sewer pipes are treated with cork. All heating mains and any warm air ducts connected with the exhaust system that otherwise would upset the heat balance are similarly treated.

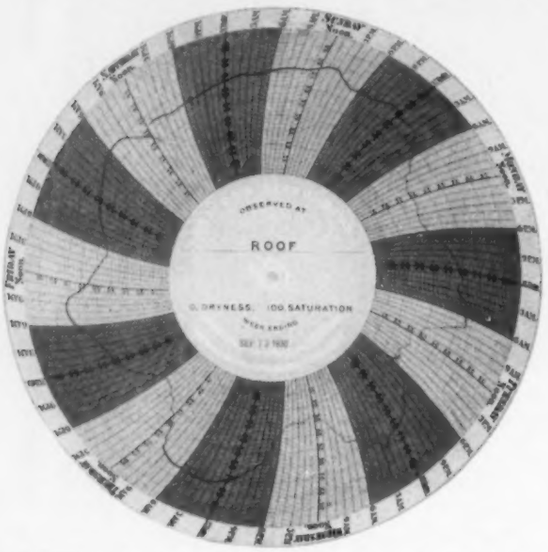
Three Types of Humidification

Three different types of humidification are used within the plant. About 15 per cent of the air conditioned space is served by small filter units, and 85 per cent is handled by means of central air washing.



THE SPINNING SECTION IN MILL NO. 4

The older buildings utilize oil filters, manually cleaned. All screens are washed clean daily at four p.m., and always from 20 to 30 pounds of mud can be recovered. One evidence that the factory air is clean is seen in the fact that painted surfaces within the plant stand up for

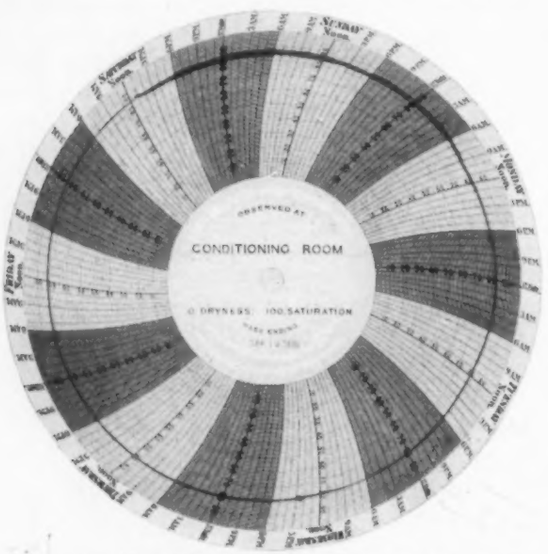


A Typical Hygrometic Chart Showing Out-Door Readings

eight years without renewal. The Oscar Heineman Corporation has utilized air conditioning for twelve years.

Separate Exhaust System for Receiving Room

Mr. Duckman is himself responsible for the design and installation of a separate exhaust system that must



A Typical Hygrometic Chart from an Air Conditioned Room Taken on the Same Day as That Shown Above

be mentioned as a supplementary system of importance. In the receiving room for raw materials, a basement room, the air was always dense and hot and disagreeable with the characteristic odor of raw silk. Pedestrians passing by the basement windows made complaint of the outpouring air as a nuisance.

Mr. Duckman contrived an exhaust system beneath an areaway between two buildings. The suction chamber is served by two fans of 480 c.f.m. each. Exhaust ducts that serve the sorting, boiling, and drying processes draw the air out and away from the workers and exhaust it through the roof. The drying rooms are similarly exhausted and a large steam cabinet in the main factory which is utilized to set the twist in thread is connected to this system. The testing room has a separate fan exhaust. Cabinets and ducts are insulated so that no heat radiates from dryers, maintained constantly at 150 F. This separate exhaust system is cheap, simple, and effective, states Mr. Duckman.

Testing the Threads

On the top floor of building No. 4, 100,000 reels of single ply raw silk are wound on spindles at the same time. The fragile hygroscopic threads are rendered strong enough by air conditioning to revolve the reels by tensile strength. It is a delicate and nice adjustment. There is little bristling; static is well controlled.

The filmy threads, when wound, are tested. Four sets of forty test panels are made up from every ten bales processed. The test panels are wound 100 threads per inch, and each panel carries a 450-meter length of thread. Evenness of product in the basic grade must not be lower than 78.0 per cent for three-fourths of the panels tested, and auxiliary tests of several types are used to supplement this visual inspection in artificially day-lighted rooms for evenness.

Ten bales for one day's product in a plant would mean the work of 1,000 reeling girls. They represent some 1,330 pounds of raw silk or 8,100 skeins. Each pound means winding a continuous raw silk thread 300,000 meters long.

Silk grades are high and constant only when room air is moist. Conditioned air with good control, therefore, finds strong support in the silk industry. Its future there is certain.—*S. P. M.*

Hydraulic Press Operation

REGARDING the article[1] on figuring water for hydraulic presses, I would like to add a few ideas:

Where the idle stroke happens to be too great for the work in question (the press may have been purchased for a different operation) I have found it advantageous to put a clamp around the ram and let this clamp rest on the stuffing box when the ram is in the outward position, giving just the proper opening of the platens to accomplish the work.

When operating a two- or multiple-pressure press it is usually a saving to squeeze the press as far as it will go with the lighter pressure, then apply the higher pressure by means of a two-pressure valve.

The size of the pumps can be reduced materially by having an accumulator on the line with sufficient capacity to take the requirements of the press during its heavy working stroke and then build up the volume in the accumulator during the idle stroke of the press, proper allowance being made for leakage, etc.—*Mark W. Roe*, Mechanical Engineer, Kelly-Springfield Tire Company.

[1] "How to Figure Amount of Water Used by Hydraulic Presses," by F. G. Schranz and W. L. Delaney. Heating, Piping and Air Conditioning, February, 1931, p. 135.

PRACTICAL PIPING PROBLEMS

A Right and Wrong Way to Install Box Unions in Industrial Pipe Lines

by W. H. WILSON

Installing Box Unions

The box union is a pipe fitting that is often used to advantage for conveniently installing or for allowing for the removal of piping.

This union is used and applied to the pipe, generally, without taking into consideration which end of the union is faced toward the flow in the pipe line. In the majority of cases this probably would make no material difference and is seldom, if ever, questioned.

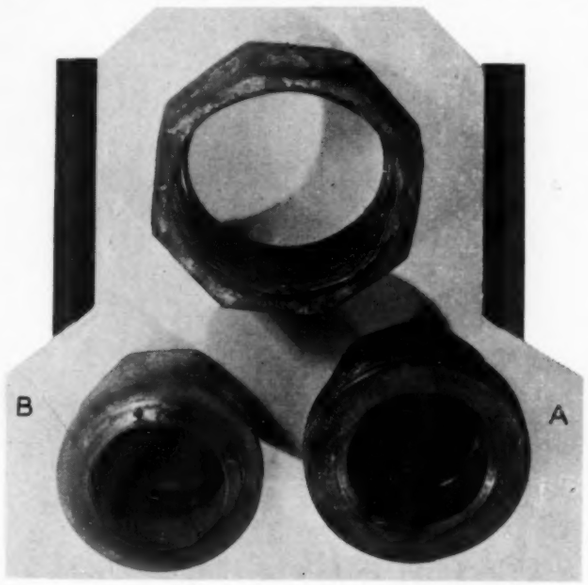


FIG. 1—GROUND JOINT UNION REMOVED FROM A LINE CARRYING SATURATED STEAM AT 125 POUNDS. THE LEAK WAS CAUSED BY THE STEAM IMPINGING ON THE SEATING FACE, AS SHOWN AT *B*

Box Union in 125-Lb. Line

The illustration, Fig. 1 shows a box union (size, 1½ in.) of the ground joint pattern that was removed, after being in use for several years, in a steam line carrying 125 pounds per square inch saturated steam pressure.

The flow through the line was from the end of the union having the male thread, shown at *A*. The steam impinged on the face of the ground joint of the opposite end of this union which is inserted in the collar, shown at *B*, causing the seating face to become worn and scored, as shown by the marks at the top of the seating face, causing the joint to leak.

This example would seem to show that when a union of this or a similar type is installed, provided there are no other requirements, it would be better to put the union on the other way in order to allow the flow in the line to come through the other end of the union and prevent it from impinging directly on the seating face.

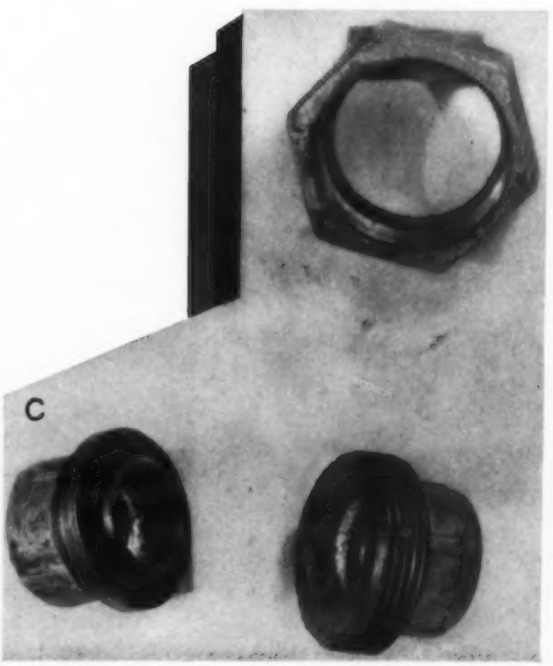
It should be understood that in some cases—for example, in places with limited room or where there are obstructions—it is necessary to place the union so that it can be readily tightened and in these cases the flow would probably have to be disregarded.

Projecting Lip Worn Away

Fig. 2 shows a union of the gasket type. The projecting lip for holding the gasket in position would offer resistance to the flow. This can be observed by looking over unions of this kind that have been in use; frequently a large portion of the lip is worn away by the flow of the contents of the pipe line when this part of the union is placed so that the flow is allowed to strike directly on the lip.

All other things being in favor, the writer thinks it advisable to face these unions so that the flow through the pipe line will not strike directly on the lip or the seating face.

FIG. 2—A BOX UNION OF THE GASKET TYPE. THE PART OF THE UNION CONTAINING THE LIP REFERRED TO IS SHOWN AT *C*



Conventions and Expositions

National Industrial Congress and Exposition, National Management Congress: April 13-18; Cleveland, Ohio. Executive Committee, 819 Citizens Building, Cleveland.

American Oil Burner Association: Convention, April 13-18; Benjamin Franklin Hotel, Philadelphia.

American Society of Mechanical Engineers: Semi-annual meeting, April 20-23; Birmingham, Ala. Meeting at Hartford, Conn., June 1-3. Secretary, Calvin Rice, 33 W. 39th st., New York City.

National Warm Air Heating Association: Annual Convention, April 22-23; Deshler-Wallick Hotel, Columbus, Ohio. Managing Director, Allen W. Williams, 3440 A. I. U. Bldg., Columbus, O.

American Welding Society: Annual meeting, April 22-24; New York City. Secretary, M. M. Kelly, 33 W. 39th st., New York City.

American Society of Refrigerating Engineers: Spring meeting, May 6-8; Hotel President, Kansas City, Mo. Secretary, David L. Fiske, 37 W. 39th st., New York City.

1931 Midwest Bituminous Coal Conference: May 21-22; University of Illinois, Urbana, Ill. Chairman, Program Committee, B. R. Gebhart, Illinois Coal Bureau, 307 N. Michigan ave., Chicago.

Heating and Piping Contractors National Association: Annual Convention, May 6-9; Kentucky Hotel, Louisville, Ky. Secretary, Joseph C. Fitts, 50 Union Square, New York City.

National District Heating Association: Annual Convention, June 2-5; Statler Hotel, Boston, Mass. Secretary, D. L. Gaskill, 603 Broadway, Greenville, O.

American Society of Heating and Ventilating Engineers: Semi-annual meeting, June 22-25; Swampscott, Mass. Secretary, A. V. Hutchinson, 51 Madison Ave., New York City.

National Association of Power Engineers: Annual convention and exposition, September 7-11; Convention Hall, Kansas City, Mo. Secretary, F. W. Raven, 417 S. Dearborn st., Chicago.

Southern Power and Machinery Show: October 19-24; Textile Hall, Greenville, South Carolina.

Third International Conference on Bituminous Coal: November 16-21; Carnegie Institute of Technology, Pittsburgh, Pa. Chairman, Thomas S. Baker, President, Carnegie Institute of Technology.

Recent Trade Literature

Boiler Controls: National Regulator Co., 2301 Knox Ave., Chicago; 16-page catalog describing the features, operation, installation and results obtained with steam damper regulators and over-fire control for boilers. (15 to 300 lb.) Operation is discussed at some length.

Cold Storage Doors: York Ice Machinery Corporation, York, Pa.; 34-page, looseleaf data book giving very complete information and detailed drawings of many types of cold storage doors and vestibules.

Expansion Joints: Croll-Reynolds Engineering Co., Inc., New York City; four-page pamphlet describing construction details and features, and giving dimensions, etc., of expansion joints for steam, air, water, gas and oil lines and other lines carrying hot fluids.

Meters: The Brown Instrument Company, Philadelphia, Pa.; 32-page, carefully illustrated catalog on electric CO_2 meters—indicating and recording. Combustion waste, the principles of operation of the meters and their installation and operation are considered. Also, a large folder on electric steam flow meters and the general question of charging departments with steam.

Radiation: C. A. Dunham Company, 450 E. Ohio St., Chicago; 16-page booklet on concealed radiation, showing installation views and methods of installing.

Pressure Regulators: Watts Regulator Co., Lawrence, Mass.; folder describing several types of pressure regulating and reducing valves.

Pressure Regulators: Natural Gas Equipment, Inc., Petroleum Securities Building, Los Angeles, Calif.; 60-page book, fully illustrated with photographs and installation charts, on automatic pressure regulation for gas, steam, liquids or vapors. Among the headings are pressure regulators, reducing regulators, back pressure regulators, gas fuel regulators, pump and compressor governors, motor valves, vacuum and differential regulators, balanced lever valves, and liquid level controllers.

Pumps: The Duriron Company, Inc., Dayton, Ohio; four-page data folder on self-priming centrifugal pumps for handling special materials. Rating charts, material lists and suggested uses are covered, as well as features of these pumps.

Stokers: Combustion Engineering Corporation, 200 Madison Ave., New York City; folder giving dimensions, capacities, drawing, and a discussion of a stoker unit of the self-contained underfeed type with electric drive and integral fan. It is designed for the firing of boilers up to 150 hp., and may be had in sizes to burn 300, 600 and 1,000 lb. of coal per hr.

Pumps: Worthington Pump and Machinery Corporation, 2 Park Ave., New York City; data sheets giving detailed information on horizontal duplex piston pumps, vertical single-acting power pumps, and hot oil pumps. Also a data sheet devoted to vertical, four-cycle, direct injection diesel engines.

Unit Heaters: Young Radiator Company, Racine, Wis.; 16-page bulletin including efficiency data and installation information on unit heaters of a wide range in capacity. Single speed and multiple speed units are shown, as are single and dual motor installations.

Valves: Davis Regulator Company, 2541 S. Washtenaw Ave., Chicago; folder describing automatic valve specialties for the control of flow and of pressure.

Welding: The Lincoln Electric Company, Cleveland, Ohio; announcement of an annual award for papers describing an application of arc welding.